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YOUNG

# How Typhoid

## Fever is Spread

AND

Notes on Dysentery and Cholera

1906

*Reprinted from its fourteenth report  
by the State Board of Health of Maine.*

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## HOW TYPHOID FEVER IS SPREAD.

By A. G. YOUNG, M. D., Secretary of the Board.

The demonstration that typhoid fever is a water-borne disease was a distinct advance in our knowledge of the causation of our communicable diseases. That water is often a distributor of typhoid fever is so positively established that there is no danger that it can ever be successfully assailed. Nevertheless, the collector of these notes believes that the fact that typhoid fever is often spread by water has come so to overshadow in the public mind other means by which it is communicated that the efficiency of our effort to limit the prevalence of this serious disease is much lessened. Believing this he wishes to present some of the facts and observations which indicate that the public generally, and some of the members of the medical profession even, in their teachings and in their warnings to the families under their care, should take a broader view of the means by which typhoid infection is distributed and of the scope of the required precautionary measures.

*The Cause of Typhoid Fever.*—It is understood nowadays by the intelligent public generally, that typhoid fever is the result of the action of a specific kind of infection—the bacillus of typhoid fever. This infectious disease never originates *de novo*, nor as the result of a cold, ordinary disturbances of the digestive system, nor even from the uses of polluted, unclean, or decaying food or drink unless they contain, or are infected by the typhoid bacillus.

*Source of the Infection.*—This specific infection of typhoid fever always comes directly or indirectly from previous cases of typhoid fever, usually near, but occasionally somewhat remote as regards time.

*Typhoid Fever a General Infection.*—Probably the generally accepted opinion is correct that the typhoid infection is, at first, a local process confined to the intestinal tract, but recent research

leaves this point just a little doubtful. Upon the question of the general diffusion of the infection through the system, or of the frequency in which a general infection results, the teachings of even the recent editions of the text-books and of the latest observations, are hardly in accord. For instance, Professor Klemperer<sup>1</sup> says:

"In the circulating blood of the enteric fever patient the demonstration of the bacilli has also been possible—for example, in the blood of the veins, after blood has been removed by a syringe—but this appears to be exceptional. As a rule, the blood of the patient during life is sterile, the important road of transport of the bacilli appears to be by the lymph system."

On the other hand later investigators have found that the typhoid bacillus pervades the general circulatory system in a pretty large percentage of cases examined, and that this general infection occurs early in the course of the disease in a considerable number of cases at least.

"Dr. Ruediger<sup>2</sup> found that, in thirty cases of typhoid fever investigated by him, typhoid bacilli or paratyphoid bacilli were present in the blood in the earlier days of the disease. The differential diagnosis between the typhoid and the paratyphoid bacillus cultivated from the blood is easy, and the demonstration of the bacilli in the blood is comparatively simple."

Dr. Von Drigalski, a brigade surgeon at Kassel, Germany, and one of the men who is taking an active part in the advanced work in that country in the control of typhoid fever says:<sup>3</sup>

"By the way of the mouth only the bacillus of typhoid fever reaches the organism of its victim and implants itself usually, if not invariably, in the intestinal tract from which it pervades the whole system so that generally the bacilli may be found almost everywhere, particularly in the liver, the bile, in the lungs even when there is no apparent pulmonary disease; almost constantly in the mucus membrane of the stomach, in the esophagus, frequently on the surface and in the depths of the tonsils, and occasionally from the tongue successful cultures of the typhoid bacilli have been made. In the intestinal tract, they are more plentiful where the specific pathological changes have not occurred, the most plentiful in the duodenum, while they may be present only sparingly or not at all in the parts of the colon where the swollen and ulcerated glands are present. What a mass of typhoid bacilli are produced in the diseased body is

1. Modern Clinical Medicine, Edition of 1905.

2. Tr. Chicago Pathol. Soc.—*Centr. für Bak.*, XXXIII., 291.

3. *Deutsche Viert. f. öff. Ges.*, XXXVIII., 22, 1906.

almost incredible. There is hardly a secretion or excretion of the patient which does not contain the germ. In the perspiration, however, it has not as yet been demonstrated with certainty."

J. L. Hirsh,<sup>1</sup> Professor of Pathology in the University of Maryland, with the aid of two assistants, examined the blood in 100 cases of typhoid fever and found bacilli present in the circulating blood in 78 and absent in 22 cases. The largest number of positive findings were in the second week of the disease, but in 16 cases examined during the first week, 12 were positive. His conclusions are that the bacillus typhosus is present in the circulating blood in every case of typhoid fever some time during its course; that the bacilli invade the blood very early in the disease; and that they usually disappear from the blood by the end of the third week.

Hirsh opens his paper by saying that "the views regarding the nature of typhoid fever have undergone considerable changes in recent years. While this was formerly considered as an intestinal disease, or as a disease with especial localization in the intestinal tract, the modern conception regards it as a true septicemia. Instead of local lesions in the intestines with subsequent blood infection, the organisms of the disease are first conveyed to the general circulation and the intestinal lesions, when present, are to be regarded as the secondary changes."

Auerbach and Unger<sup>2</sup> in their investigations as to the presence of the typhoid bacillus in the blood of typhoid fever patients, obtained it from the blood in seven out of ten cases in which a definite clinical diagnosis had been made.

In twenty-eight cases of typhoid fever, all severe cases, Courmont and Lesieur<sup>3</sup> succeeded in showing the presence of the typhoid bacillus in the blood by inoculating from 2 to 3 c. m. of blood into 250 c. m. of bouillon. They succeeded thus in making cultures of typhoid bacilli from the first day to the third week.

*How is the Infection Excreted?*—If typhoid fever is so frequently a general infection, it suggests that the range of possible danger extends to a larger number of the excretions from the

1. *Jr. of Am. Medical Assoc.*, XLVI., 1922. 1906.

2. *Deutsche Viert. f. öff. Ges.*, XXXIII., 142 1902.

3. *Deutsche Viert. f. öff. Ges.*, Sup., XXXVI., 148. 1905.

typhoid patient than it has been usual to take into account in our regulations designed to prevent the spread of the infection. While we are still to consider the discharges from the bowels as the main source of infection, other excretions require thorough disinfection or destruction.

In the report of Drs. Reed, Vaughan, and Shakespeare, constituting the commission appointed to investigate the prevalence of typhoid fever in the U. S. military camps in 1898, the following opinions are expressed:

"The stools of individuals sick with typhoid fever constitute the most important source for the spread of this disease, and it may be stated in a general way that typhoid fever is due to the transference of some part of the feces of an infected individual to the alimentary canal of one susceptible to this infection. This transference in exceptional cases may be quite direct, as when a careless nurse soils her hands with the dejections from her typhoid fever patient and eats her food without disinfecting her soiled fingers. Generally, however, the transference is more indirect and the germs in the infected stools may multiply through many generations and be transported by water or otherwise through considerable distances. Moreover, as has been indicated already, the bacilli may pass through an intermediate host, which may be man or one of the lower animals. An immune individual may visit a distant city, the water supply of which is infected with the typhoid bacillus, and he may carry this infection to his village home, where it may be deposited in his normal stool, may find its way into the local water supply, and cause an epidemic of the disease.

"It should be borne in mind that typhoid stools are infectious often before the individual shows any evidence of the disease. In other words, the stool of a man in the incubation period of typhoid fever may be laden with the bacilli of this disease. In this way every latrine in an encampment may be infected with the specific micro-organism of typhoid fever before the disease has developed sufficiently in the individual to be recognized clinically. On the other hand, the stools may continue to be infectious long after convalescence has set in. So great is the danger of the spread of this disease from infected stools that in all cases where fecal matter can not be removed by water carriage, or otherwise, from immediate proximity with human habitation, all stools, those of both sick and well, should be thoroughly disinfected."

The most significant result of recent investigations is that the urine of typhoid patients frequently contains the typhoid bacillus in enormous numbers, and that such persons, disseminators of infection, may constitute serious sources of danger far into the

period of convalescence and even sometimes until long after the recovery of the patient appears to be complete.

A further, significant fact is that the expectoration of the typhoid fever patient may be dangerously loaded down with the bacillus:

"In 1890, Neumann demonstrated typhoid-bacilli in the urine of 11 out of 48 cases examined. His results were received with some skepticism, however, and received no confirmation until Petruschky, in 1898, published the results of cultures from the urine in 50 cases, with isolation of *B. typhosus* from 3. Later, Richardson obtained the bacilli from 23 out of 104 cases examined—22.1 per cent.; and Horton-Smith obtained them from 11 of 39 cases, 28 per cent.—the urine containing at times as many as 50,000,000 organisms in each cubic centimeter. During the past year, 1900-1901, from the urine of 55 typhoid fever patients in the Johns Hopkins Hospital the typhoid bacilli were isolated in 19 cases."<sup>1</sup>

Richardson<sup>2</sup> found that typhoid bacilli may remain in the urine for weeks and months, thus exposing to danger persons in the neighborhood of the convalescents. In the expectoration of typhoid fever patients with lung complications the typhoid bacillus is present in the sputum, together with the pneumococcus and the influenza bacillus. The urine and the expectoration of typhoid patients must therefore be carefully disinfected.

Stefanalli and Cumbo<sup>3</sup> studied twenty-one cases of typhoid fever and for each case a bacteriological examination of the urine and blood was made, and the Widal test was employed. From this study they conclude that the typhoid bacillus may be found in the urine at any time in the course of the disease whether it contains albumen or not. They thus found the bacillus in 30 per cent. of the cases. Its presence may be transitory or last through the whole course of the disease.

According to Schuzer,<sup>4</sup> in 599 cases of typhoid fever the typhoid bacillus was found in the urine in 177 cases, or in 29.5 per cent. of them.

Burdach<sup>5</sup> found the bacillus in 10 of 25 typhoid fever patients and he refers to the investigations of other observers upon 360

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1. Typhoid and Typhus Fever, Nothnagel's Ency. of Pract. Med. p. 34, 1902.

2. *British Medical Journal*, Feb. 5, 1903.

3. *Rivista Crit. di Clin. Medica*.

4. *D. Viert. f. öff. Ges.*, XXXIV., 153. 1903.

5. *Zeit. f. Hygiene*, XLI., 305, 1902.

patients, in 129 of whom or in 33%, the bacillus was present in the urine.

The urine, says Drigalski,<sup>1</sup> may be entirely clear and normal in appearance and yet contain an abundant quantity of the typhoid bacilli, and the dejections which appear to be entirely normal may contain the infection until long into the period of convalescence. At the time particularly when the clinical convalescence is progressing and appetite and digestion are again restored, the excretions of the typhoid bacilli are particularly frequent and plentiful, so that the bacterial flora of the stools sometimes consist of a pure culture of the typhoid bacillus.

Naturally the frequency of this phenomenon varies, and fortunately not every convalescent is such a source of new infections. I have found the bacillus present in the excretions of the patient in 15% of the cases in the first 5 days; in 11% still present after 8 or 10 weeks; in 4% longer than 3 months. For the reason that the convalescent is frequently excreting the infection after he has resumed his ordinary life and is in close communication with others, he is particularly dangerous to his associates.

Houston<sup>2</sup> reported a case of cystitis of three year's standing due to the infection of the bladder with the typhoid bacillus. An interesting point in this case is that the patient never had typhoid fever, but had nursed cases of that disease.

In Jehle's<sup>3</sup> examination of the expectoration of typhoid patients he found the bacillus present in nine out of fifteen cases. In all these cases typhoid was complicated by bronchitis or broncho-pneumonia. The typhoid bacilli existed in pure culture in 2 cases, in 4 cases they existed very numerously, in 2 cases they were associated with the influenza bacilli, and in 1 case with diplococci and streptococci.

The results of the examination of the bronchial mucus were as follows: In 5 cases in which there existed hæmorrhagic infiltration of the lungs the typhoid bacilli were found 4 times. In 6 cases with simply a congested condition of the lung tissue the presence of typhoid bacilli were proved 4 times.

Numerous observations have shown that the typhoid bacillus retains its vitality for a long while when enclosed in the inflammatory exudates which are the result of its action in various parts

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1. *Deutsche Viert. f. öff. Ges.*, XXXVIII., 23, 1906.

2. *British Med. Jr.*, 1899, I., 78.

3. *Wiener Klin. Woch.*—*Public Health*, XIV., 630, 1902.

of the body, for instance, in purulent collections in periostitis, abscesses of the muscles and elsewhere, in cystitis, but these exudates are infrequent sources of infection. The main and the most frequent sources of supply of infection are the discharges from the bowels and the urine, and next to those the sputum, particularly where there are indications of pulmonary involvement.

*Life of Typhoid Infection Outside the Body.*—The life history of the bacillus of typhoid fever after it leaves the human body, its power of resisting adverse influences, and of retaining its vitality, have been the subjects of an immense amount of patient and careful investigation. Briefly stating some of the results, it may be said that direct and unobstructed sunlight rapidly destroys the life of the bacillus, but its power of resistance is greater than that of many other pathogenic micro-organisms, or, partly protected from its action, it perishes more slowly. Drying is not so rapidly destructive of its vitality as was formerly assumed. Dried in the dark it remains actively viable many days. It easily survives any degree of cold found in nature and remains uninjured by repeated freezings and thawings. By heat Sternberg found that the typhoid bacillus is destroyed at the temperature of 140° F., and Bessenge confirms this statement when this temperature is continued five minutes. Under the conditions of the outer world, the various other bacteria found under natural conditions in water, in the soil, etc., inhibit the growth of the typhoid bacillus or cause it to disappear. Even when exposed to the competition of the bacterial flora in natural waters, its survival of a few days to a month or more confirms the observation of epidemiological study as to the danger from water infected with this specific bacterium. In the polluted soil around houses or out-buildings, the infectivity of the typhoid germ may continue some months at least. It finds a congenial culture fluid in milk, and, in the laboratory, the bacteriologist secures a rapid growth of it upon the cut surface of a boiled potato. Upon clothing and in rooms the infection may persist for a long time under favorable conditions, such as frequently pertain to fabrics and dwellings.

All those facts call for careful, intelligent measures for safeguarding human environments from being seeded down with the infection of typhoid fever.

*How May Typhoid Fever be Contracted?*—In the investigation of the sources of infection in outbreaks of typhoid fever, and of the means through which the infection reached its victims, the search, if intelligently made, cannot be confined to a few long-accepted ways in which the infection may have been received. The investigation must be comprehensive enough to include all of the methods of transmission which recent research has shown are probable or even only possible.

In the following notes which indicate some of the methods by which typhoid fever is spread, there is no attempt to enumerate them in the order of their importance. To arrange them thus would be somewhat difficult. While the medical profession generally holds the opinion that infected water is the most frequent cause, the experience of some health officers leads them to give infected milk a very high rating as a medium for the distribution of typhoid infection. Again, competent observers have found that, for their localities, and in the communities in which they have made their observations, "contact infection" has manifestly been a leading factor.

The arrangement which follows is that of presenting first and prominently some of the epidemic factors of typhoid fever which have until recently received but scant attention in this country.

*Contact Infection.*—There is developing a close parallel between the three chief enteric epidemic diseases—typhoid fever, Asiatic Cholera, and dysentery. That will be shown in the appended "Notes on Dysentery and Cholera." While their epidemic extension through the medium of polluted water has long been recognized, their spread from person to person as contagious diseases, or by "contact infection" has received too little attention.

In the report\* which was made on the prevalence of typhoid fever in the U. S. military camps at the end of the Spanish War in 1898, by the very competent commission (Drs. Reed, Vaughan, and Shakespeare) appointed to investigate the matter, are found the following:

"Camp pollution was the greatest sin committed by the troops in 1898." \* \* \* "Infected water was not an important

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\* Abstract of Rpt. on the Origin and Spread of Typhoid Fever in U. S. Military Camps During the Spanish War of 1898. pp. 179-183.

factor." \* \* \* "It is more than likely that men transported infected material on their persons or in their clothing and thus disseminated the disease. We have condemned the method which was followed in many of the camps of detailing men from the ranks to act as orderlies at the hospitals. In some of the commands it was customary to detail 100 or more men from the line every morning. These men went to the hospitals, handled bed pans used by persons sick with typhoid fever, and at night returned to their comrades. The most of these men were wholly ignorant of the nature of infection and the methods of disinfection. In fact, at one of the division hospitals we saw orderlies of this kind go from the hospital and partake of their midday meal without even washing their hands. These men handled not only the food which they ate, but passed articles to their neighbors. It seemed to us that a more certain method for the dissemination of an infectious disease could hardly have been invented."

The medical division of the office of the Prussian War Department\* has published a work which presents the prevailing opinion at the present time among the leading authorities upon the subject of typhoid fever in military experience. This pamphlet states that great epidemics of typhoid fever are due to the fact that many men are exposed to the bacilli which are excreted by the sick. Most frequently drinking water is the medium through which infection is conveyed, in many cases, however, food which has been infected with the excretions of the patient is the medium of communication. The communication of the infection often occurs as the result of personal association with the sick. The infectious material may be conveyed by the clothing, bedding, by various utensils and articles which have come in contact with the sick. The rooms formerly occupied by typhoid fever patients may be infected so as subsequently to communicate infection to other persons. The spread of the disease is also favored by the pollution of the surface of the ground with typhoid discharges and by the want of local cleanliness. The early recognition of the first cases of typhoid fever which occur is emphasized as offering the possibility of preventing the further spread of the infection. Quarters that have been vacated by the sick should be thoroughly disinfected, and the clothing of the patient and all the articles used by him must undergo efficient disinfection.

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\* *Deutsche Viert. f. öff. Ges.*, XXXIII., (Sup.), 154. 1902.

A discussion on typhoid fever before the German public health association in September, 1905, brought out some interesting points in regard to contact infection.\*

Drigalski said: "Epidemics of typhoid fever due to contact are slow in their course. There is a gradual rise and fall in the curve of prevalence which differs from the suddenness of the outbreak when the infection is referable to an infected water or milk supply. In the latter case there is usually a sudden rise and a sudden fall with a smaller prevalence of the disease due to contact infection."

Springfield states: "Exacerbations of the typhoid fever curve which may appear periodically or irregularly are due in a great majority of cases to massive infection. The single cases of infection are due either to importation or to secondary infections following the original infection. In industrial centers the imported cases are not more than 10% of the total. The single infections (contact infection) usually occur 4 weeks after the primary case and usually in the vicinity of the house where the first case has occurred or upon the same street. In due time the third series of cases may occur, and thus the prevalence of the disease may be continued, case linked with case, chainlike."

The following interesting statement of opinion and of fact was made by Professor Fischer of Kiel: "A great number of cases of typhoid fever are due to contact infection. Infection in this way comes most frequently to the persons who care for the sick and quite a per cent. of the cases under my observation have been among trained nurses. In Kiel, for example, we had in the latter half of the past year only 50 cases of typhoid fever. Five of the hospital nurses contracted the disease. In the preceding year one of the sisters engaged in the care of a typhoid patient took the disease. Two of these sisters died. It is possible that even these trained nurses were not careful enough. That was shown in the case of one, but with the others there was no reason to assume that this was true. Our experience leads to the conclusion that it is difficult in the care of these cases to avoid the danger of contact infection.

"I wish emphatically to state that it is not only in private houses that contact infection occurs, but in hospitals as well, where every precaution is supposed to be taken through disin-

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\* *Deutsche Viert. f. öff. Ges.*, XXXVIII., pp. 22-65. 1906.

fection of the discharges and otherwise to avoid the danger; and here is a point which I would suggest: whether we should not give the nurses who are thus endangered a protective inoculation. It is true that our experience in regard to this method of immunization is not great, but the question may be raised whether, when persons are especially endangered, it may not be desirable thus to seek to protect them. There are other conditions under which I may be allowed to suggest the desirability of protective inoculations. I remember one outbreak which occurred this year. In a factory in which about 200 men and women worked within a short time, 30 cases of typhoid fever occurred. We were obliged to discharge these patients from the hospital at the earliest date. The hospital was full and it was impossible to retain them longer. There was nothing else to do but to discharge them and let them take their places again in the factory. In this instance a protective inoculation would have been in place."

Professor Griesbach remarked: "In the discussion before this Association we have heard that virulent typhoid germs may be discharged from the organism weeks after convalescence. Further it is easily possible that children who are suffering with suspicious gastric or intestinal symptoms and disease of respiratory organs, and are at the same time attending school, may be transmitters of typhoid fever. The disease may be transmitted through the medium of drinking cups in common use by the children, or through the clothing, by means of books, or otherwise.

"School teachers and directors of schools should in all cases be promptly notified of the appearance of typhoid fever in any of the families in which children live who attend their school. It should then be the duty of the school physician to keep the pupils under observation who have associated with persons who may be the transmitters of typhoid fever. When children present symptoms a bacteriologic investigation of these people is emphatically required, and the children from the families in which there are cases of typhoid fever should be permitted to reenter school only after they have been under the observation of the physician and have been under bacteriologic control."

Dr. Demuth said: "The history of an outbreak of typhoid fever which I will narrate has, I think, the value of a scientific

experiment. In a large ward in a hospital there occurred successive cases of typhoid fever in spite of the strictest precautionary measures against accidents of this kind. We were at first unable to discover any cause for these cases. An appeal was made to the Director of the Bacteriological Station to make an investigation. The result was that he found two patients in this ward who, in their excretions, were giving off typhoid bacilli. These two patients were isolated and thereupon the recurrence of the cases of typhoid fever ceased suddenly. Two nurses were constantly employed in this ward, and this outbreak of fever in the ward was felt the more keenly because every new nurse who had been sent to this ward, six altogether, took the disease. The two patients, carriers of infection, who were isolated were put in charge of a nurse who had previously had typhoid fever. In the course of the summer this nurse left and a new nurse, assigned to duty in the barracks where these two patients were still isolated, came down with typhoid fever in three weeks. After a year had passed both of these carriers of infection were still excreting typhoid bacilli."

Dr. Bestelmeyer, a surgeon on the general staff of the Bavarian Army, stated emphatically in this discussion: "The people generally should be taught that typhoid fever is directly infectious, from person to person, and they must also be taught the danger of infection from impure water and infected milk."

Professor William T. Sedgwick of Boston, who is widely known among other works for his distinguished ability in investigating outbreaks of typhoid fever, wrote the following words in relation to the spread of typhoid fever in Bondsville, Mass., a manufacturing village where water-borne and milk-borne infection was excluded:

"Children abound; and, as there are no fences, and because it is the custom, they mingle freely, playing together and passing from house to house. The families are of that grade in which food always stands upon the table; meals are irregular except for those who must obey the factory bell. The children play awhile, then visit the privies, and with unwashed hands finger the food upon the table. Then they eat awhile, and return to play. Or, changing the order of things, they play in the dirt and eat and run to the privy, then eat, play, and eat again, and this in various houses and in various privies. For them, so long as they are friendly, all things are common,—dirt, dinners and privies; and to illustrate exactly how secondary infection

may go on, I may describe in detail one case which I personally witnessed. A whole family (of six or more) was in one room. Four of them have the "fever." Two of these were children in the prodromal stage. A table stood by the window covered with food, prominent among which was a big piece of cake. It was early September, and a very warm day; but every window was shut and the odor was sickening. Flies innumerable buzzed about resting now on the sick people, now on the food. A kind hearted neighbor was tending the baby. By and by one of the children having the fever withdrew to the privy probably suffering with diarrhoea, but soon returning, slouched over to the food, drove away some of the flies, and fingered the cake listlessly, finally breaking off a piece, but not eating it. Stirred by this example, another child slid from his seat in a half stupid way, moved to the table, and, taking the same cake in both hands, bit off a piece and swallowed it. The first boy had not washed his hands, and if the second boy suffered from secondary infection, I could not wonder at it.

"This was one case; but I have seen so often the table of food standing hours long in the kitchen and serving as one station in the dirty round of lives like these, that it is easy for me to understand how dirt, diarrhoea and dinner too often get sadly confused. Personal filth is apparently the principal agent of secondary infection.

"Thus far I have not even touched upon one feature of the life of this little community, which deserves careful consideration. There was for most or all of these houses a sewer connection for the sinks but not for the privies. Much, perhaps most, of the garbage found its way into the privies. These had been obviously in bad condition, and, from some, filthy streams ran down between them and the houses. In and around these streams the children played. Given any original imported case, the infection might easily have reached these trickling streams. Children's fingers might thence carry the germs to the food, and thus the journey of the germs from one living intestine to another be completed. Or, again, given in such a community an imported case and no disinfection, as was the condition here at first, the importer while in the early stages handles with unclean hands food for others; or the clothing of such a person gets infected and is handled; there need be then no difficulty in completing the history. It follows as a matter of course."\*

*Finger Infection.*—That the fingers of persons attending cases of typhoid fever are, without intelligent cleansing and disinfection, dangerous to their owners and to other persons, is indicated in some of the preceding, and more pointedly in the following quotations.

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\* 24th Annual Report of State Bd. of Health of Mass. p. 736. 1892.

"With reason," Drigalski remarks, "work with the typhoid bacillus is considered one of the most dangerous kinds of laboratory work. If for years we remain unaffected while doing this kind of work, we may thank the efficacy of the sublimate washing. We have not to fear inoculation through the hands as when working with plague infection. The typhoid organism infects only by the way of the mouth."

In an epidemic of typhoid fever in Springfield, Mass., investigated by the local board of health and by Dr. Magrath,\* assistant secretary of the State board of health, it was found that the regions where the cases were the most numerous were those occupied by the poorer, and in many cases, the poorest people in the city. Cases followed no line of water distribution, and there was no reason to incriminate either the milk supply or the ice supply. A close study of all the conditions led to the conclusion that the main factors in the spread of the disease were the many peddlers of fruit and vegetables. It was ascertained that in a number of instances cases of typhoid fever had been present in the families of these small venders themselves, and the conclusion was that the infected material being present on the hands of any persons, these venders or others handling bread or fruit, or vegetables to be eaten uncooked, the transferrence of the infection to those articles of food would be an easy matter. In addition to the means of spread here outlined it was thought that there had in all probability been operative locally in the spread of this epidemic transmission by means of flies. It is certain that in particular localities conditions existed favorable to spread by this means: open vaults, broken windows, domestic uncleanness, coupled with the occurrence of cases of the disease, furnishing all that was required for such transmission.

In the discussion of the paper by Dr. Magrath, Prof. Sedgwick said that: Of course, hand to hand, and finger to finger, and mouth to mouth spreading is one way in which the slow and insidious spread of typhoid fever can be done. He referred to his experience in Bondsville in 1892, in which case he attributed the transmission of the disease very largely to the filthy handling of food and to the playing of children in filthy gutters which had been infected from houses having cases of typhoid fever in them.

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\* Am. Jr. of Public Hygiene, XV., 467. 1905.

In another place, Professor Sedgwick and Wilson\* say:

Food, fingers, and flies offer an alliterative summary of the most common agents. The one thing upon which we can fix our attention with certainty is the common point of departure. Every germ of typhoid fever, whatever its subsequent history, originates in the body of a typhoid patient and leaves it in the excreta. Every case of typhoid fever is due to the presence of excreta on food or fingers, or in some other place where excreta should not be. Filth is the fundamental condition for the spread of typhoid fever; cleanliness the universal panacea for its eradication.

One fact which stands out with especial clearness the longer we study the subject is that in spite of all that may be, and has been, said to the contrary, typhoid fever is a contagious disease. Instead of saying, as is often said, that "typhoid fever is infectious, not contagious," we need to say to-day that "typhoid fever is both infectious and contagious;" and, doubtless, it is in part for this very reason that it has been found so difficult to exterminate.

*Transmission by Clothing.*—"When a command badly infected with typhoid fever changes its location it carries the specific agents of the disease in the bodies of the men, in their clothing, bedding and tentage. This is shown by the fact that when commands changed location, leaving behind them all their sick, and when they went to places free from the infection the disease continued with them. Even an ocean voyage does not relieve an infected command of its infection. This was shown in the study of the various commands that went to Cuba and Porto Rico. After a command becomes badly infected with typhoid fever changes of location, together with thorough disinfection of all clothing, bedding, and tentage is necessary." †

The *British Medical Journal* gives the following as the "real facts" in regard to an outbreak of typhoid fever which occurred on board the training ship "Cornwall":

"Ten cases of typhoid fever having occurred on the training ship 'Cornwall' early in April, an investigation into its origin was duly undertaken; and as no other cause was found, attention was at last directed to certain blankets recently taken into use. Stains on them awakened suspicion, and examination by Professor Klein, F. R. S., proved that the blankets were swarming with typhoid bacilli in an active condition. The blankets

\* Jr. N. E. Water Works Assoc., XX., 51, 1906.

† Report on Typhoid Fever in U. S. Military Camps during War of 1898, p. 185.

in question had been offered to the authorities of the ship at an unusually low rate and as the sample submitted was good, a considerable number were at once bought. All the blankets concerned were army blankets, and the question that next arose was how they came to be upon the market at all, whether clean or unclean."

Apparently a very large number of blankets—many thousand—which had been used by the British troupes in South Africa in hospitals and elsewhere were sold by the government, it is said at the vile price of five cents apiece, and in due course found their way to London, and were widely scattered.\*

Curschmann narrates the following incident: †

"A number of years ago the following instructive experience occurred to me: A young merchant living in middle Germany, who was accustomed to send a portion of his clothing and linen to his home in Hamburg to be laundered, continued this practice when attacked with "gastric fever." Ten and twelve days respectively after the sister of the patient and a servant had washed the linen, they became ill, the one with a mild, the other with a severe attack of typhoid fever. That the brother had also suffered from the same disease was unfortunately demonstrated by autopsy, death occurring from copious intestinal hemorrhage in the course of an apparently mild attack."

"In 1886 a woman who had been called to one hamlet to nurse her children returned to her home, was taken sick with typhoid fever and communicated the disease to her nurse, and subsequently fifty other cases developed which could not be traced to soil pollution or infected water supply. From this locality three children were admitted to the hospital at Bonn; here four persons were attacked who had come in direct contact, and five washer women who had come in indirect contact, i. e., through the clothing and linen of the patients." ‡

In the German army barracks various instances have developed indicating that typhoid fever has been spread by clothing. In one of the barracks typhoid fever had for a long while been present. Suspicion finally fell upon the bed linen and clothing. It had been discovered that three of the recent cases who had used the clothing had been attacked with typhoid fever and the linings of the trousers were almost without exception soiled with dried fecal matter. The clothing was submitted to a thor-

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\* Boston Medical and Surgical Journal, CXLVIII., 649. 1903.

† Nothnagel's Encyc. of Pract. Med.—Typhoid Fever Volume, p. 55.

‡ Rpt. St. Bd. of Health, Iowa. 1897, p. 148.

ough cleansing and disinfection. From that time on no more cases of typhoid fever appeared.

In a second history of typhoid fever in one of the German barracks the same results, complete cessation of the prevalence of the disease, followed a thorough disinfection of the clothing.

That the bacillus of typhoid fever, dried upon ordinary fabrics, retains its life for a long while is evinced by experience and experimental investigations.

Heim\* found that typhoid bacilli on silken threads retain their vitality 213 days in the dark.

At the conclusion of his experimental work for the purpose of determining the power of resistance of the typhoid bacilli against drying and the possibility of their transportation through the air in a virulent form, Prof. Uffelmann† sums up his results as follows:

The typhoid bacillus remains alive and virulent for at least 21 days; in white sand for at least 82 days; in dirt for more than 30 days; on linen from 60 to 72 days; on "buckskin" from 80 to 85 days; on wood for at least 32 days.

The conditions and the results of these experiments teach that typhoid bacilli resist for a considerable time the influence of a continued drying when the action of sunlight is excluded. They teach also that viable and virulent typhoid bacilli in the dust or filth from the ground, houses, the streets, and clothing may be transported through the air so as to infect milk and other articles of food. The possibility of the transportation of infection through the air must therefore be acknowledged. It is questionable, however, whether the infection can come through the respiratory organs, but probably may through the mouth by being swallowed.

*Typhoid Houses.*—It has been observed that typhoid fever has recurred successively at intervals of months or years in certain houses. In some of these houses the explanation is that the typhoid bacillus has retained its vitality a long while, sometimes in rooms which were not disinfected after the earlier cases, and sometimes in polluted grounds from which nearby springs or wells have received drainage. A new explanation

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\* Zeit. f. Hyg., L., 123. 1905.

† Centr. f. Bak., XV., 133. 1894.

for some of these outbreaks is that persons in these houses who had typhoid fever continue for a long time to give off the infection in their excretions.

"In these cases of long continued excretion of typhoid bacilli," says Drigalski, "it is not necessary to look for pathologic changes in the organs. The continuous excretion of the infectious germs sometimes continues in persons who are entirely free from all signs of disease. These observations of mine date back to the beginning of 1903, and in two years I have found in 900 cases of typhoid fever 300 persons, 33% of the whole, who continued to excrete the typhoid bacillus for a period of time longer than ten weeks. In one case it continued for a year and a half almost in pure culture in the urine; in one, for more than nine months; in two, more than seven months; in one, six months; and in seven cases, more than three months."

That the floors, furniture and bedding of barracks may become infected and continue to be infective for a long time has been shown in the experiment of some of the European army surgeons. An instance is a report made by Chour, a Russian medical officer:

Two regiments of infantry stationed at Jitomir and using the same water supply were unequally affected with typhoid fever. One showed a sickness rate of 9.6 per 1,000 in 1885, and 3.2 in 1886 from that disease. The other regiment had at the same time a typhoid morbidity rate somewhat greater; one company particularly was severely affected in 1886. There were 14 cases of typhoid fever among the ninety men. This intensive prevalence in this company suggested the idea of a localized cause of some kind in the room where the men were lodged. In December, 1886, the quarters occupied by this company were evacuated and an energetic disinfection of the walls, floors, clothing and bedding was carried out. After the execution of these prophylactic measures, the company again occupied its quarters. The typhoid sickness rate was reduced to 1.7 per 1,000 in 1887 and there were no cases whatever in 1888. Now it developed that during the same period of time in those rooms of the barracks which had not been submitted to disinfection, typhoid fever persisted and gave a sickness rate of 22 per 1,000 in 1887, and 33 per 1,000 in 1888. This remarkable disappearance of typhoid fever in the rooms which had been carefully disinfected and its persistence in those others which had not been disinfected, confirmed the theory of a local cause.

The rooms were immediately evacuated and the men were quartered in the woods in the vicinity of Jitomir. Three cases appeared among the men within the period of incubation of

typhoid fever, but after that and the disinfection and renovation of the rooms, the epidemic was extinguished.\*

Referring to typhoid houses Schleghtendal† narrates the following history:

“In a farmhouse each new servant who came to the house came down with typhoid fever, as also all the children who were born in this house had the disease during their childhood. How long back this recurrence of cases of typhoid fever had occurred in this house is unknown. There was a failure to discover any conditions which offered a solution to the cause of the continued presence of typhoid fever. In the nineteen cases which he records the interval between the succeeding cases varied from two months to five years.”

*Typhoid Distribution by Flies.*—In the report‡ on typhoid fever in the military camps in 1898, flies we are told, undoubtedly served as carriers of the infection. Flies swarmed over the infected fecal matter in the pits and then visited and fed upon food prepared for the soldiers at the mess tents. In some instances where lime had recently been sprinkled over the contents of the pits, flies with their feet whitened with lime were seen walking over the food.

It is possible for the fly to carry the typhoid bacillus in two ways. In the first place, fecal matter containing the typhoid germ may adhere to the fly and be mechanically transported. In the second place, it is possible that the typhoid bacillus may be carried in the digestive organs of the fly and be deposited with its excrement.

Dr. Pötter,§ medical officer of health of Chemnitz, Germany, told of an outbreak of typhoid fever which appears to have been due to transmission of infection by flies.

“While in Leipzig there was a tenement house in one of the suburbs of Leipzig in which in rapid succession eight cases of typhoid fever were reported all which occurred in one-half of the house. There were two tenements on each floor. In the two tenements on the north side of the house the typhoid fever occurred. In the tenement in the other end of the house there was not a single case. Each tenement had its own privy. In the tenement in which the cases of fever were found the privy was located just off from the kitchen. For the tenement in the

\* *Traite de Medicine*, II., 51, 1899.

† *Zeit. f. Med. Beamte*, XVI., 641, 1903.

‡ Report of Drs. Reed, Vaughan and Shakespeare.

§ *Deutsche Viert. f. öff. Ges.*, XXXVIII., 64, 1906.

other end of the house there was no direct communication between the privy and the living-room. When the cover of the privy in the north part of the house was opened a swarm of flies always came up. Some of the flies were sent to Prof. Fischer in the laboratory of the Hygienic Institute of Leipzig, and typhoid bacilli were found in these flies in large numbers. His investigation showed that the typhoid bacilli which had been eaten by these flies retained their vitality for a period of twenty-three days.

Dr. A. W. Martin,\* medical health officer of Gorton, England, referring to figures which he gives relating to diarrhea says that they give every indication that there is a cause operating during the warm months of the year and which is absent during the colder parts. "Since 1898 I have tried to show year by year in my annual reports, the connection between this disease and the domestic fly. A hot, dry summer produces an abundance of flies and diarrhea makes its appearance in about a week after the flies appear in large numbers. The diarrhea sickness fluctuates and keeps pace with the temperature of the atmosphere, which is much influenced by the rainfall, and also the number of flies keep pace with the temperature of the atmosphere and the rainfall. The atmospheric changes are but secondary causes in the producing of the disease, namely as influencing the appearance and disappearance of the common house fly, and also as affecting their numbers. During the summer a privy vault was examined at the house of a typhoid case; the flies were hanging in bunches and wading and sucking up the liquid excreta, flying directly into the kitchen, into milk vessels, and onto food exposed on the table."

In a report made by a committee of experts appointed to investigate the source of infection in an outbreak of typhoid fever in the jail of New Haven county, Connecticut, it is stated that typhoid attacked only the prisoners, twenty cases in all.

Neither did they find any evidence that the character or quality of the food in itself was chargeable with the outbreak. They found, however, that the food was sometimes exposed for a little while on tables; the windows of the apartment being opened and not screened, it was readily accessible to flies. Having found no satisfactory evidence that the infection had been introduced into the jail in water, milk or other articles of

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\* Public health, XVII., 711. 1905.

food, their attention was given to the discovery of any sources of infection in the vicinity outside the jail.

It was found that in the adjoining street there were five dwellings adjoining the jail property in which cases of typhoid fever had occurred from the 22d of August to the 17th of September, and that the privies in the rear of these houses were in a very foul condition, "and in several instances fecal matter was found lying exposed on the surface of the ground."

It was the opinion of the committee that the occurrence of cases of typhoid fever in adjacent houses had infected their filthy privies, and the abundance of flies with the open communication through the windows between the kitchen and the adjoining yards, was in all probability the method of transmission of infection.

Sangree, after calling attention to the enormous number of flies present at the military camps where typhoid epidemics occurred, gives the results of some experiments he performed, which were designed to show the ability of flies to carry infection. He allowed flies to remain half a minute on an agar culture of anthrax bacillus in a Petri dish; he then placed them upon a sterile agar plate, and found that at every point where the fly's foot had trod anthrax colonies developed. The same was also shown on potato. It is reasonable to suppose that the same results could have been obtained with the typhoid bacillus.\*

*Danger From the Sputum.*—The exhaled air from the lungs of the typhoid fever subject is germ free, as it probably is in all infectious diseases. There is therefore no possibility of this disease being spread by means of the air exhaled from the lungs. This statement is true only when the exhaled air is free from sputum. In the pneumonias that complicate typhoid fever the Eberth bacillus is found in the diseased lungs and may be eliminated in the matter coughed up and disseminated through the air in the fine spray that accompanies severe fits of coughing. However, the spread of typhoid fever in this manner must be regarded as a bare possibility.†

Dr. P. W. Williams,‡ assistant physician to the British Royal Infirmary, reports five cases of typhoid fever as tending to prove

\* Med. Record—Maryland Med. Jr., XLIII., 19. 1899.

† Rept. of Reed, Vaughan and Shakespeare in U. S. Military Camps in 1898.

‡ British Med. Jr., 1892, Vol. II., p. 1353.

that this disease may be communicated by the breath, or expectoration of infected persons.

In the first case the patient was delirious, and for some days had a good deal of laryngeal and bronchial catarrh, and was constantly coughing and expectorating about the bed. Later there was a relapse with symptoms of acute laryngitis. The autopsy confirmed the diagnosis. The lungs were extremely congested and the lower lobes of both lungs were consolidated. Typhoid ulceration in larynx. He was admitted to the Royal Infirmary on the sixth day of his illness.

Cases two and three were brothers of the first case. They were removed to the Bristol Union Workhouse. Their disease was of a severe type, but there were no special laryngeal symptoms.

The fourth case was the nurse who attended the first case in the Infirmary. She died.

In the fifth case, it was thought the man contracted the disease from the first patient who had the laryngeal complications. This fifth case was a fatal one, and, post-mortem, the bacilli of typhoid fever were found in the typhoidal ulcerations which were present in the larynx.

In investigating the sputum of eleven typhoid patients bronchitis was present in ten, and in one pneumonia developed. In this last patient the typhoid bacillus was present in the sputum for a period of ten days. Edel,\* who observed these cases, advises that the sputum of typhoid patients be disinfected with solutions of carbolic acid or lysol.

Typhoid bacillus was also found by Dieudonné† in the expectoration of a typhoid fever patient. The disease first assumed the form of a pneumonia but later clinical symptoms of typhoid fever presented themselves with the typhoid spots and enlargement of the spleen. Widal reaction was also positive. Typhoid bacilli also were present in the sputum seven weeks after the patient was received at the hospital and after the patient felt entirely well.

*From Wells and Springs.*—The history given by Dr. Austin Flint, Senior, of an outbreak of typhoid fever in the village of

\* Fortschr. d. Med.—*D. Viert. f. öff. Ges.*, XXXIV., 140, 1903.

† Centr. f. Bak., XXX., 481.

North Boston, N. Y., in 1843 was one of the important pieces of work which furnished indubitable proof of the agency of polluted water in spreading typhoid fever. He says:

"The fever was at first imported to that place by a young man from some place in Massachusetts, who, arriving at North Boston by stage, took lodgings at the tavern on the 21st of September, where he died on the 19th of October, 28 days after his arrival.

"In this little hamlet were nine families, consisting of 43 persons. Between October 14th, five days before the date of the death mentioned, and December 7th (twenty-one days), twenty-eight of the forty-three persons comprising this little community, were attacked with the fever, and in ten instances the disease proved fatal.

"An important part of the history of this epidemic, says Dr. Flint, remains to be stated. At the time of writing the report from which the foregoing extracts are taken, and for many years afterwards,—indeed, up to a recent date,—I had no idea of the diffusion of typhoid fever through the agency of drinking water. At the time of the epidemic nothing had been published on the topic, and at the time of writing this report, and long afterwards, I was not aware that any one had entertained this view of the causation,—there was nothing relating to it in the medical literature of the country.

"All of these nine families but three used water for drinking and culinary purposes from the same well,—that belonging to the tavern. Two of the three families not using it, did not on account of their distance from it, and the intervention of a stream some three or four rods wide. Their intercourse, however, with the others was free and familiar. The other family who did not use the water was at enmity with the proprietor of the tavern, and had been forbidden its use.

"So strongly did the circumstances at that time seem to point to the tavern well, as the source of the contagion, that suspicion was aroused and charges of poisoning the well were openly made against the family who, alone in the immediate vicinity of the well did not use of its waters, and did not suffer from the disease.

"It can hardly be doubted that the exemption from the disease of the family of Stearns (who did not drink the water), was due to the animosity of the inn-keeper, which led the latter to prohibit the use of his well, and compelled Stearns to dig a well of his own. The two families living forty rods from the tavern escaped because, owing to the distance, they did not obtain water from the inn-keeper's well.

At the time of the epidemic no suspicion of the presense of the special cause in the drinking water being entertained, pains were not taken to note the situation of the privies, the nature of

the soil, etc. In order to obtain some information on these points I wrote recently to Dr. P. Barber, at the date of the epidemic, and until lately, a practitioner in that neighborhood. Dr. Barber writes that, according to his recollection, the privy attached to the inn was three or four rods from the well, and he recollects that the contents were allowed to accumulate. The well was by the road-side, supplying with water the inn and the stables, as well as the immediate neighbors." \*

The history of the North Boston outbreak is cited as one of the important early observations. Since then innumerable observations have been made which show plainly the dangerous character of polluted well water.

The following may serve as a late instance. It is related by George A. Soper,† as a part of the aftermath which followed the outbreak of typhoid fever in Ithaca, N. Y. It was the result of the contamination of a well on the property of a man named Barnes. "The Barnes well had been famous; people who had learned to fear the city water went to the Barnes well with a feeling of perfect safety. No one had ever been made sick from drinking this water. So great was the demand upon the well that the water was actually piped to another house. Many of the people who had been drinking from the Barnes well were taken ill. In all there were fifty cases of typhoid and five deaths traced to this well.

"When suspicion was directed to the well, I visited it and had the drain pipe from the water closet in the Barnes house excavated. The drain ran within three or four feet of the well. When the laborers dug the earth from beneath the drain, they found that the joints had been scamped; that is, insecurely and improperly closed. When the water closet in the Barnes house was flushed, the water would run through the drain to a point about ten feet from the well, whence it would flow out into the porous soil through the leaky joint and so into the well. On analysis, the water of the well was found to be grossly polluted.

"We needed, however, to find out how the drainage which entered the well had actually infected it. It was then discovered that Mrs. Barnes had suffered, some weeks before, with a mild attack of typhoid fever, which had been pronounced by her physician to be gripe. We proved the real character of her disease by taking a specimen of her blood and examining it in the laboratory. The dejecta from this patient passed down through the water closet without disinfection; it escaped from

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\* Third An. Rpt., State Bd. of Health of Mich., p. 64.

† Jr., N. E. Water Works Assoc., XVIII., 445. 1904.

the drain pipe into the well and, as we have said, occasioned fifty cases and five deaths."

Konradi\* refers to a remarkable epidemic of typhoid fever in a village containing 450 inhabitants, in which during the first week of the epidemic about forty cases appeared, and within six weeks the total number had run up to 200. The infection was traced to the well in the market-place and used by all the people. A man came from another village infected with typhoid fever. He dwelt near the well and it could be shown that the soakage from the dejections which were emptied upon a pile of manure could easily find its way into the well. The well was closed and the epidemic soon ended.

Dr. C. O. Probst, Secretary of the State board of health of Ohio, gave the history of an outbreak of forty cases of typhoid fever with five deaths in a little town of four hundred or five hundred inhabitants in that state. There was a stone quarry about half a mile from the center of the village. A peculiarity of the geological formation was that it consisted of limestone ledges and this limestone was cracked in all directions, readily admitting a flow of water for a long distance as we discovered by experiment. The stone quarry, which was 26 feet deep by measurement—a little deeper than the wells—was being pumped out when I arrived at the village. When it was completely emptied of water, the wells for three-quarters of a mile were either entirely dry, or drained to a depth of two or three feet, there being very little water in the wells at that time. I found that they had had three cases of typhoid fever in the spring of this year. This happened only a month ago. The board of health, on the appearance of typhoid fever, ordered a cleaning up of the town. It was found that two barrels of night soil had been taken out and thrown into the stone quarry. This was discovered when the stone quarry was pumped dry. When the wells became lowered by the drouth there was evidently a flow of water from the stone quarry into the wells of the village, and the cases of typhoid fever commenced. I think, said Dr. Probst, many facts might be mentioned to show that it is possible in certain sections, where we have a peculiar geologi-

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\* Centr. f. Bak. (Orig.), XL, 31. 1905.

cal formation, for the wells to be polluted by cesspools or privy vaults, thus causing typhoid fever.\*

A similar geologic formation exists in some parts of this State, notably in sections in Aroostook, where in one instance a new cellar dug and blasted into a ledge was nearly filled with water by a heavy shower, but it all disappeared downward through the ledge before the next morning.

The historic example of Paris illustrates the danger of the transmission of infection long distances beneath the surface of the earth in certain geologic formations. In the French capital there was a very high death-rate from typhoid fever from 1881 to 1890.

The water for the city was obtained from the Vanne, the Avre, the Dhuis and the Lunain. The earth in the region from which these sources of supply were located consisted of chalk in which in all directions there was a plentiful network of connecting cracks and rifts. This chalk is covered with a thin layer of clay and gravel. Through these rifts in the chalk the ground water circulates freely and here and there comes to the surface in the form of springs. The water which circulates in these subterranean passages, on account of its large quantities of carbonic acid, dissolves the openings in the chalk thus continually widening them. Thus there has resulted the formation of veritable subterranean brooks and streams. This enlargement of the fissures in the chalk leads finally to the formation of caverns, the roof of which is formed by the strata of clay and gravel. Where these roofs have fallen in sinks or holes in the ground result. All the surface water which reaches these subterranean galleries comes to the surface in the springs without sufficient filtration. This water is clear, cool, and of unobjectionable taste. By pouring into these sunken places fluorescein, lycopodium, and one of the yeasts, the connection between these springs and these caved-in places was demonstrated, a fact which a knowledge of the geological formation had previously indicated. Fluorescein was also poured into holes bored in the earth at various places. By this means the extent of the ground surface which fed the particular springs was determined. The rapidity with which the coloring matter made its way in these

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\* Rpts. and Papers of the Am. Pub. Health Assoc., XIX., 265. 1893.

subterranean water-courses varied from 90 to 100 meters in an hour. By the method of Cambiers the drinking water of the city was examined every 3 days, and that of the springs daily for typhoid bacilli. After a small outbreak of typhoid had occurred upon the drainage area of the Vanne, typhoid bacilli were found in the reservoirs fed from these sources.\*

The degree of the danger of the infection of wells from sources of pollution on or in the ground surrounding wells depends largely upon the character of the strata entering into the composition of the ground. When it is, for some considerable distance downward, finely granular and homogeneous in structure, sand or sandy loam for example, there is less danger. In coarse sand or gravel, the filtering action of the soil can less be trusted. The danger is intensified by the presence of seamy ledges, or where there is rather a thin soil overlaying an impermeable stratum of rock or clay.

*Life of the Typhoid Bacillus in the Ground.*—The following observations relating to the life of the typhoid bacillus has an important bearing upon the question of the infection of wells, springs, and other water supplies.

Levy and Kayser† published the following observations bearing upon the duration of the life of the typhoid bacillus.

On the 8th of September, 1901, in the evening, Herrb returned from a journey to S., a suburb of Strasburg. He was then not feeling well, but did not call a physician until the 13th. As his physician suspected typhoid fever he immediately ordered the disinfection of the stools. On the 15th of September the patient was transferred to the hospital. The dejections of the patient had been emptied into the privy vault which is a water-tight cement vault. From the 8th of September in the evening until the 13th at noon the dejections were not disinfected. The vault was emptied February 6, 1902, and the contents were spread upon the surface of a garden. In samples of earth taken from this garden on the 20th of February the typhoid bacillus was shown to be present. The typhoid bacillus had therefore endured exposure to the sun and atmosphere and winter temperature 5 months in the vault and 14 days upon the surface of the ground. From the 6th to the 10th of February there were frequent storms, partly rain and partly snow.

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\* Hygienische Rundschau, XIII., 105. 1903.

† Centr. f. Bak. (Orig.), XXXIII., 489. 1903.

The following notes are taken from a paper by Prof. Almquist\* of Stockholm, upon the question of the preservation of pathogenic bacteria in manure heaps.

The first time that I succeeded in cultivating pathogenic micro-organisms in polluted earth I took the earth from the entrance of a cow stable. The sample there taken consisted of stone, sand, and loam plentifully mixed with manure. Later I made use of a sample taken near a pigpen and from near a slaughter-house which possessed similar characters.

Hitherto I have used only manure which has been composted for some time so that it was black and humus-like. The earth was sterilized in an autoclave at a temperature of  $120^{\circ}$  C. Only distilled water was added. Some of my investigations show that the typhoid bacillus at the temperature of  $24^{\circ}$  C. in manure or earth varies in its degree of development. In many cases the maximum point of multiplication was reached within the first week; in other cases it was two weeks before this point was reached.

The bacteria of typhoid fever, cholera, and dysentery grow with particular luxuriance in old well-rotted manure and in earth which has been manured. Their multiplication is sometimes, indeed, more plentiful than in ordinary peptone bouillon. I assume that it is possible, after these disease germs have reached the maximum of vegetation, that their existence may be continued. This has been shown for sterilized manures. In samples which are not sterilized, the development of the flora and fauna is enormous—bacteria, streptothrix, protozoa, of various varieties constitute a lively *wirrwarr* in which I have not yet succeeded in determining the fate of disease germs.

At the present stage of our knowledge I maintain that the theory is correct that the germs of typhoid fever, cholera, and dysentery when distributed in drainage from manure heaps and in earth which has been manured can multiply. If this is correct the specific germs of these three diarrheal diseases have two culture fields where they may thrive: in the human digestive organs and in the fertilized surface soil near our dwellings.

The experiments of Almquist show the following facts:

That in fertilized earth as well as in pure manure after its sterilization and the addition of a sufficient quantity of water, the specific micro-organisms of cholera, typhoid fever, paratyphoid, dysentery, and bacterium coli multiply at various temperatures.

The multiplication of typhoid bacilli reaches its maximum point more slowly at  $24^{\circ}$  C. as a general rule than at  $18^{\circ}$  C. The maximum point of the curve is sometimes not reached earlier than

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\* Zeit f. Hygiene, LII., 179. 1906.

two weeks. By the addition of 2 or  $1\frac{1}{2}\%$  of common salt the growth of the cholera and typhoid bacteria is luxuriant and the maximum point of multiplication is more quickly reached. The virulence of typhoid and cholera bacteria may remain unimpaired in manure heaps and polluted earth for several weeks.

The biology of these pathogenic germs as well as their epidemiology justifies the theory that these micro-organisms have the power of multiplication outside of our dwellings in the damp or aqueous portions of manure heaps and of polluted soils.

For several years, the Medical Officer of the Local Government Board of England carried on experimental work for the purpose of determining the period during which the typhoid bacillus retains its vitality in the soil. Dr. Sidney Martin\* commenting on his two previous reports on this subject says, that the general conclusions to be derived from the previous work are:

1. That in sterilized garden soils and in sterilized soils from the entourage of houses, i. e., in what may be called organically contaminated soils, the typhoid bacillus lived and multiplied, whether the soil were kept at a uniform temperature of  $37^{\circ}\text{C}.$ , at the temperature of the laboratory (between  $15^{\circ}$  and  $19^{\circ}\text{C}.$ ), or at the temperature of an outside shed (between  $3^{\circ}$  and  $15^{\circ}\text{C}.$ ).

2. That in these soils the bacillus was still alive after 404 days, and that for a short period it retained its vitality after the soil had been so dried that it could be readily reduced to a powder.

3. That in virgin soils, soils which had never been manured or cultivated and which consisted chiefly of sand or peat, the bacillus did not grow nor live; that in the majority of cases, even on the day following inoculation of the soil with the bacillus, no evidence of its presence in the soil could be obtained.

In experiments with unsterilized soils the doctor was almost invariably unable to find the typhoid bacillus after a very short lapse of time. But in one implantation of natural, unsterilized soil the typhoid bacillus was recovered after fifty days.

Dr. Robertson of England, showed that when typhoid germs were sown into earth soaked with animal filth, the germs can live through the winter and the next year may multiply so that an area containing filth may probably remain infected from year to year.

Under the inspiration of former investigators Rullmann went over practically the same ground as Martin in his experiments. He mixed loam with equal parts of fine-grained gravel. A

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\* 28th Annual Report, Loc. Gov't Board, Rpt. of Med. Officer, p. 382.

part of the samples were sterilized, others were not when they were exposed to the diffused light in a room. Although the vessels containing the samples were larger than those used by Martin the typhoid bacilli had penetrated all parts of the masses of the earth at the end of one month. In one sample these micro-organisms were present nine months, and in another sixteen months after inoculation. They were present nearly a year in one sample which consisted mostly of red river sand. In the unsterilized samples of humus and fine gravel typhoid bacilli were quickly destroyed. In another variety of earth typhoid bacilli were found for a period of 100 days. The diversity of results obtained by Rullmann were by him ascribed to the chemical action of earth of different compositions.

Wurtz and Bourges determined by their experiments that pathogenic micro-organisms which were put upon the surface of the ground or inoculated at a depth of ten centimeters appeared upon the leaves and the stems of plants growing in this earth, a fact which had already been determined regarding tetanus germs. In spite of the bactericidal power of direct sunshine and the washing of the plants by the rainfall they showed that plants may be transmitters of infection.\*

In the experiments of E. Pfuhl† the typhoid bacillus remained alive in damp garden earth 88 days, and in dry sand 28 days.

A young woman returned from Ulm to her home village of Riedheim, sick with typhoid fever. Her dejections were thrown upon a pile of manure. After a period of five weeks it was carted away and four of the five persons who were engaged in this work came down in due time with typhoid fever. In like manner the dejections of these patients were thrown upon another manure heap and nine months later the manure was hauled away. Of the men who were employed at this work all came down with typhoid fever who had not already suffered an attack.‡

The history of this outbreak is sometimes referred to as indicating the transmissibility of typhoid infection through the air. It may not prove this, for the hands may have been the medium of transmitting the infection to the mouths and intestinal canals of these laborers. It does, however, appear to show that the infection of typhoid fever may retain its vitality and its virulence for a long time in material of this kind.

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\* Cited by Levy and Kayser—Centr. f. Bak. (Orig.), XXXIII., 489. 1903.

† Zeit. für Hygiene, XL., 555. 1902.

‡ Real-Encyclopädie der Gesam. Heilkunde. Band I., 13. 1880.

The results of the experimental work which has been cited together with those of earlier work, when the methods of identifying the typhoid bacillus had not reached that stage of certitude which now exists, are confirmatory of the conclusion which has been drawn from the study of epidemics, that earth which contains much dead organic matter—polluted soil—when once infected with the typhoid bacillus may retain that infection in a virulent form for months, and perhaps for years, contributing a share of its infection now and then to near-by wells, and possibly in other ways endangering human beings. The recognition of this latter possibility does not by any means require the acceptance of Pettenkofer's theory.

But, in favor of the well as a source of water supply in rural life, it may be said that, in most parts of this State, good, pure water may be obtained from the ground if the well is properly constructed and is sufficiently distant from manifest sources of pollution.

*From Public Water Supplies.*—How the infection in the stools of one typhoid fever patient may infect a large number of persons and thus give rise to a frightful epidemic was strikingly shown by the outbreak in Plymouth, Pa., the lesson of which is worth repeating, again and again.

From early in January until early April a man was sick with typhoid fever at his home near the banks of the stream and above the intake which supplies Plymouth with water.

During the course of his illness, his dejecta passed at night, without any attempt at disinfection, were thrown out upon the snow and frozen ground, toward and within a few feet of the edge of the high bank, which slopes precipitously down to the stream supplying the town with water.

The nurse in charge states explicitly that in emptying the chambers at night she did not stand on the porch to throw out the contents, but stepped down some distance and threw them toward the creek. If she stepped but a few feet away from the porch, she would empty the excreta within twenty-five or thirty feet of the edge of the stream.

The dejecta passed during the day were emptied into a privy a little farther back, the contents of which lie almost upon the surface of the ground, and at the first thaw or rain they too would pass down the sloping bank and into the stream. These dejecta were thrown out from time to time until the accumulation no doubt equaled the daily passages from many such patients. They remained innoxious upon the snow and frozen

ground until sometime between March 25 and April 1, when they were washed into the stream and thence into the third reservoir.\*

The result of this deplorable want of regard for the safety of the public was 1104 cases of typhoid fever,—713 cases in April, 261 in May, 83 in June, 31 in July, 15 in August, and one in September. The intensity of the infection, or the large dose of it received by the earlier victims, was shown by the gravity of the earlier cases,—high fever and delirium, severe and repeated intestinal hemorrhages, extreme prostration, slow convalescence, and tendency to relapse.

This is a good example of an explosive outbreak of typhoid fever—that is, of the sudden attack of many persons within a short time. This was undoubtedly due to a massive infection of the water. The mountain stream from which the water supply was taken, is small. The spring rains suddenly washed into it the accumulated discharges of the typhoid fever patient.

Dr. Springfield,† in a discussion before the meeting of the German public health association last year said:

“We think of water infection only when a large number of the users of the water suddenly become sick, but my experience shows that the appearance of the disease due to water-borne infection may be sudden or gradual, depending upon the degree of infection of the water. The number of persons infected does not depend alone upon the degree of pollution. Much probably depends upon the virulence of the culture. Even in cases where there appears to be a gross pollution or infection of the water only a small per cent. of the persons who use the water may be attacked. The remainder appear to be immune either as the result of a previous attack of typhoid or otherwise.”

A recent outbreak fully as severe but not falling quite so suddenly, was the one which they had in Ithaca, N. Y.

As the result of indifference through a series of years to the dangerous condition of its water supply, a frightful epidemic of typhoid fever appeared in that university town in the first quarter of the year 1903. With a population given by the last census as a little over 13,000, it is estimated that 1,350 cases of typhoid fever occurred, with 82 deaths in a little more than three months. No less than 522 homes were visited with the

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\* First An. Rpt. St. Bd. of Health of Pa., p. 176. 1885.

† *Deutsche Viert. f. öff. Ges.*, XXXVIII., 45. 1906.

disease; in over 150 of these there were two or more persons attacked. Dr. George A. Soper,\* consulting engineer and sanitary expert of New York City, who was employed to investigate the outbreak, says that there was no doubt that the drinking water supplied by the Water Company was the original cause of the outbreak, but it was evident that the disease was transmitted from person to person through carelessness and ignorance in nursing the sick.

Dr. William R. Stokes† reports from the Bacteriologic Laboratory of the State of Maryland an outbreak of typhoid fever which occurred in a city with about 12,000 persons, in which one side of the city was in one state, and the other side was in a neighboring state. Each half of the town had a separate water supply. In the north side of the city practically no fever occurred. The towns were divided by a certain street, and it was said that the line of demarcation between the infected and the non-infected portion of the city was a striking feature of the outbreak. The infected part of the town received its water supply from a spring in a hollow, while the uninfected portion was supplied with water from a spring some distance away in the hills. The bacteriologic examination of the water of the infected half of the city showed the presence of 9,600 bacteria per c. c. and the presence of the colon bacillus.

This outbreak reminds one of the epidemic of cholera in Hamburg, Germany, in 1892. Hamburg with its polluted and infected water supply from the Elbe, had an epidemic of 18,000 cases of cholera, and 8,000 cholera deaths, while Altona had comparatively few cases. In Hamburg 1.3 % of its population died of cholera but in Altona the percentage of deaths was only 0.2 %. They both lie upon the same side of the Elbe, and are practically one city, as intimately coalesced geographically as are Brookline and Boston, Mass., and much more so industrially. Both cities took its water from the Elbe, Hamburg above the two cities, but where the sewage pollution was undoubtedly carried to the intake by tidal flow, Altona from below both cities where the sewage hugs the shore. Altona, however, had a good modern system of water filtration which conferred her comparative immunity.

\* Jr., N. E. Water Works Assoc., XVIII., 431. 1904.

† Jr. of Am. Med. Assoc., XLIV., 595. 1905.

Tavel\* reports the following instructive instances of local infection of a water system with typhoid bacilli which occurred in the city of Olten. This city takes its water supply from the Jura, and Tavel designates this water bad. In the second half of October, 1900, at a time when the water supply did not equal the demand, twenty cases of typhoid fever occurred in the higher lying parts of the city. As the outbreak occurred suddenly the water supply was suspected. Infection at the intake was excluded, but there was a suspicion of infection within the limits of the city. The water in the mains is under high pressure, from 5 to  $7\frac{1}{2}$  atmospheres. When water was drawn there followed in the higher laying quarters of the city a strong backward movement of the water in the pipes. The water in a stationary washtub, for example, which happened to be connected with the faucet at the time the water was drawn elsewhere, was withdrawn from the tub by aspiration, the connecting hose acting as a siphon. Thus polluted water found its way into the water mains in the locality where most of the cases occurred. There was a man sick with typhoid fever who, a little while before the sudden outbreak, had returned from the Paris Exposition. From this place they think that, in such a way as has been indicated, typhoid infection was received into the mains, when the water pressure in this part of the city was absent. Among the persons who became sick in October there was a child, G. L. While elsewhere in the city from that point of time on, no further cases of typhoid fever occurred, in the family where this child lived there were seven additional cases. This child became sick October 30, and died December 5. December 7 the child's grandmother was taken sick and was sick until January 2. The mother took her bed December 23, but had already been ailing for two weeks. She died January 8. Then there was a pause in the outbreak. March 16, 1901, a son in this family became sick, and April 12, the servant girl. April 16, a niece, and three weeks later the nurse who on April 18 had taken the place of the niece who hitherto had acted as nurse. These persons had, in spite of emphatic commands not to do so, used unboiled water. Those persons only in this household who abstained from the using of unboiled water remained free from

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\* Center. f. Bak., (Orig.), XXXIII., 166. 1903.

typhoid fever. In this house and the surroundings there were the best sanitary conditions. Just below the house occupied by this family there was stretch of water main  $11\frac{1}{2}$  meters long which served as a "dead end." In this piece of pipe there could have been but little circulation. In other words, the water was stagnant, although in the house of L. when the water was drawn it is likely there was some movement of water from this dead end. April 29 and 30 the end of this pipe which was closed was opened, and the filthy water which was found in it was examined bacteriologically. Aside from colon, proteus, and fluorescens bacilli and Staphylococci, the typhoid bacillus was found. Tavel considers this, the finding of the bacillus under these circumstances and in this place, significant as indicating that the typhoid bacillus under certain conditions may retain its vitality and its infectious characteristics for several months in water.

*The Vitality of the Typhoid Bacillus in Water.*—The question whether the use of polluted water, or water which receives sewage, will produce typhoid fever has many times been answered affirmatively by the results of the experiments to which man has subjected himself or to which he has been subjected by his municipal governments. Aside from these, much work of a scientific character has been done for the purpose of determining the action of waters of various kinds, and of sewage upon the typhoid bacillus. Only a little of the literature of this work is here cited. It shows the general trend of results, that is, that the bacillus of typhoid fever remains alive under varying circumstances for periods ranging from a few days to many. In research work of this kind the same difficulty is met in the search for the bacillus in natural, unsterilized water which is encountered in seeking it in unsterilized soil—the overwhelming growth of micro-organisms which find their natural habitat in these waters.

The experiments of Laws and Andrews for the London County Council indicated that the life of the typhoid bacillus in sewage is brief. The experiments of Dr. Klein for the Local Government Board confirms the observation that the typhoid bacillus, kept in ordinary fluid sewage, has not only no tendency to multiply, but, on the contrary, diminishes in numbers and ultimately dies. On the other hand, these experiments show

that the bacillus coli retains for a long time in sewage its vitality and its power of self-multiplication.

The thought occurred to Dr. Klein that the vitality of the typhoid bacillus in sewage may not be parallel to its vitality in sewage *plus* water of one and another sort, as under the natural conditions in which typhoid fever is disseminated. In his experiments, he found that when a certain quantity of nitrates were added to the sewage, it had a tendency to prolong the life of the typhoid bacillus and even to increase their number. Thus in one of the experiments, after eight weeks, the number of colonies of the typhoid bacillus had increased from 16,000 to 1,600,000.

He also found that water from the public water supplies of London after it had received a trace of nutritive material showed the presence of typhoid bacilli at the end of eight weeks.\*

Jordan and Russell† were employed by the Sanitary District of Chicago to conduct some experiments upon the life of the typhoid bacillus in the waters of Lake Michigan, the Chicago Drainage Canal, and the Illinois river. The statement of their conclusions at the end of their paper is to the effect that under conditions that probably closely simulate those in nature the large majority of typhoid bacilli in the several waters studied perished within three or four days; that it is theoretically possible that specially resistant cells may occur which are able to withstand for a longer period the hostile influences evidently present in water. Their experiments, however, show that if such resistant individuals exist they must be very few in number and constitute only a small fraction of the bacilli originally entering the water. They state that it is not their intention to claim that the behavior of typhoid bacilli under the conditions which were described is representative of all conditions obtainable in all natural bodies of water.

Russell and Fuller‡ of the Wisconsin State Hygienic Laboratory, in their experiments in testing the longevity of the typhoid bacillus found that, when exposed to the action of flowing lake water, the life of the organisms ranged from eight to ten days.

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\* 24th Rpt. Loc. Gov't. Bd. (Sup.), 95. 1894.

† Jr. Infectious Diseases, I., 641. 1904.

‡ Jr. Infectious Diseases, (Supplement No. 2) p. 40. 1906.

When the typhoid bacillus was exposed directly to the action of sewage bacteria its longevity was greatly diminished, three to five days being the longest time in which the organisms could be recovered. They think that the uniformity of their results, confirming the work of the preceding year in the waters of Lake Michigan and the Chicago drainage canal, warrants the conclusion that the longevity of the typhoid bacillus in waters is materially effected by the germ content of its surroundings. In sewage polluted waters it is unable to survive for more than three to five days, the period of time materially longer than that which is noted in normally unpolluted waters.

In 894 samples of water received from various sources Busquet\* found typhoid bacilli six times. According to Bertrand the typhoid bacillus may survive in the sediment in the lower part of masses of water for a period as long as three years. Samples of water should be investigated not only from the surface wells and from their central portions but particularly from the bottom of the well. In five of his positive results Busquet had obtained the samples of water from the bottom of the well in which some of the sediment had been taken with the sample.

Bordoni† and his fellow workers have determined that the typhoid bacillus retains its vitality two weeks in sea water.

Fischer and Flatau‡ obtained the typhoid bacillus with all its bacteriological characteristics in a sample of water sent to the laboratory. This sample came from a well in a village in which the inhabitants of two neighboring houses obtained their water from the well. Eight persons were sick in these houses with typhoid fever. In examinations made four weeks later the typhoid bacillus could not be detected in this water.

Mr. Geo. W. Fuller says that the long continued investigations at the Experiment Station of the State Board of Health at Lawrence, Mass., show that the typhoid fever bacillus continues to live in the waters of the Merrimac river, in greatly diminished numbers, for a period of at least twenty-four days.

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\* *Annal. d'Hyg. Pub.—Deutsche Viert. f. öff. Ges.*, (Sup.), XXXVI., 169. 1905.

† *Giornale della Real. Soc. Ital. d'Igiene*, XXI., 500. 1899.

‡ *Centr. f. Bak.*, XXIX., 329. 1901.

*The Question of the Self-Purification of Rivers.*—In the consideration of the dangers from water-borne infection the question of the self-purification of rivers has been considered of so great importance that much scientific work has been done to elucidate it.

That rivers and other streams have some power of purifying themselves both chemically and bacteriologically is shown by the investigations of Professor Nichols\* of Boston; by Frank\*\* in examining the waters of the river Spree above and below Berlin; by Prausnitz† for the Isar at Munich; by Uffelmänn‡ for the river Nebel; by Schlatter§ for the Limmat at Zürich; by Draer§§ on the Pregel above, within the city limits, and below Königsberg; by Delépine¶ of Manchester, England, in his study of currents of water artificially conducted through an apparatus which he had devised; by Blasius and Beckurts¶¶ in the study of the waters of the Oker supplying Brunswick, Germany; by Jordan, Russell, and Zeit. in their investigations of the water of the Chicago drainage canal, and by others.

Various agencies are operative in bringing about a partial purification of polluted river waters, some of which are:

*Dilution* does not destroy bacteria, but simply lessens their numbers in a given quantity of water, if the diluting water is purer.

*Sedimentation* plays a considerable part in purification, disposing of a part of the bacterial contents of the waters, temporarily at least; but some observations indicate that the life of the typhoid bacillus is greatly prolonged in the sediment or mud at the bottom of bodies of water.

*Light* is rapidly destructive of the bacillus of typhoid fever under favorable conditions, but in deep waters, waters which are not clear, in ice and snow-covered waters and in cloudy weather, and in the night, its influence is very slight.

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\* Rpt. Mass. State Board of Health, 1875.

\*\* Zeit. f. Hygiene, III., 355. 1888.

† Der Einfluss der Münchener Kanalisation auf die Isar. München, 1890.

‡ Deutsche Viert. f. öff. Ges., XXII., 382. 1890.

§ Zeit. f. Hygiene, IX., 56. 1890.

§§ Zeit. f. Hygiene, XX., 323. 1895.

¶ Jr. State Medicine, IX., 502. 1901.

¶¶ Deutsche Viert. f. öff. Ges., XXVII., 337. 1895.

Some of the conclusions of Buchner\* based on his observations of the morning and the afternoon fluctuation in the number of bacteria in sewage polluted streams Blasius claims are erroneous. The afternoon diminution is in his opinion due simply to the smaller quantity of sewage received at that time.

*Oxygenation* has been classed as one of the factors in purification, but Whipple and Mayer† have shown that the vitality of the typhoid bacillus is favored by the presence of dissolved oxygen in waters; and as is stated on page 133 Klein found that the presence of nitrates tended to prolong the life of typhoid germs in sewage.

*The antagonistic action* of the common water bacteria is inimical to the life of the typhoid bacillus, and, at the same time, rendering its detection difficult. The energy of this antagonistic action, says Frost,‡ depends on the temperature. At rather high or ordinary temperatures the action is very pronounced, while at the temperature of the ice chest the typhoid germ may grow in the by-products of the other germs, which at higher temperatures are quickly fatal. As auxiliary to the ordinary bacteria is that of the protozoa which Hunttemüller§ considers the principal agents in the destruction of typhoid bacilli.

*Temperature* exerts an influence. In winter the process of self-purification goes on much more slowly than in summer. This with the diminished action of light undoubtedly favors winter outbreaks of typhoid fever among the users of some water supplies.

*Manufacturing wastes* of some kinds inhibit the multiplication of bacteria in waters and the organic wastes from other factories enormously facilitate their multiplication.

Even in the light of the results of all the investigations which have been made in these directions, the general demand among experts for artificial systems for the purification of sewage polluted waters by adequate modern methods before their use as public supplies, confirms the opinion of the English Rivers Pollution Commission which prompted their report many years

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\* Archiv. f. Hygiene, XVII., 179. 1893.

† Jr. of Infectious Diseases, (Supplement No. 2) p. 76.

‡ Jr. of Infectious Diseases, I., 599. 1904.

§ Hygienisches Centralblatt, I., 255. 1906.

ago that: "It will be safe to infer from the above results, that there is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation."

These notes on water-borne typhoid infection may be closed with this remark of Springfield: "From an epidemiological point of view it is probable that there is no self-purification of streams, but merely a diminution in the amount of infection by dilution and sedimentation. The distance of the intake of the water supply from the point of infection is therefore of less importance than the demonstration of the causal relation of the cases.\*

*Typhoid from Milk Supplies.*—In the popular estimation infected milk, next to infected water, constitutes the most frequent source from which typhoid fever is contracted. This is probably an error, though milk epidemics of typhoid are frequent.

A milk borne epidemic of typhoid fever, as the Monthly Bulletin of the New York State board of health says, has certain characteristics. It is generally abrupt in its onset. A fulminant outbreak of typhoid fever in a previously healthy locality always suggests it, and while any other infected food may have a similar effect, and even a public water supply may be infected on the instant, an epidemic in which numerous cases come to light within a few days may be suspected as of milk origin. Then it is widely distributed, as much so as the milk from one source usually is, not affecting a whole community as when a public water supply is at fault, not limited to a compact neighborhood where a local cause is acting. Several members of a family, of a susceptible age, are likely to be affected. All or nearly all of those affected will be found to have had milk from one vender or possibly from a special part of his milk kept separate from the rest, and a considerable proportion of the families using the same will likewise be affected. With such characteristics of an outbreak the suspected milk should be investigated along the lines which have been suggested. The acting cause was operative two weeks before the outbreak set in, and as in a recent case may have ceased to exist; this ought to be borne in mind.†

There is no reason to believe that the cow is in any degree susceptible to the infection of typhoid fever, or that her milk, before it is drawn, ever contains the typhoid bacillus. But milk is easily infected or inoculated by the fingers of milkers or other

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\* Deutsche Viert. f. öff. Ges., XXXVIII., 35. 1906.

† Wisconsin State Board of Health Bulletin.

help in dairies who themselves have recently, or sometimes remotely, had typhoid fever; it may be in an atypical and unrecognized form, or by persons who attend the sick, or by dilution with infected water or by milk vessels or utensils which have been washed with such water. It may sometimes be inoculated by flies which have access, at the same time, to privy vaults or other sources of typhoid infection.

Dr. John S. Fulton,\* Secretary of the State board of health of Maryland, reports an outbreak of typhoid fever which occurred in Elkton in that state in 1900. There were 64 persons living in thirty-nine different houses who had the disease, and all these persons obtained their milk supply from the same milkman. Three of these patients had previously been sick with typhoid fever; one in 1884, another in 1893, and the third in 1898.

An outbreak of typhoid fever in Beverly, Mass., referable to an infected milk supply was reported by Dr. Morse, medical inspector for the State board of health.†

"A visit was made to A's farm in the town of Ipswich, he being the milkman supplying these families. He had six cows at his farm, yielding about fifty quarts of milk daily, which he distributed to families in Beverly and Salem; most of his trade, however, being in the first-named city. As an auxiliary supply, he obtained four cans from B's farm, and one can from Mr. C. All of this milk obtained from these different sources was mixed, with the exception of one can, which he supplied to a family by the name of D., and which was milk obtained from his own cows. Upon questioning him in regard to the presence of typhoid fever at his home, it was ascertained that he himself had been ill with the disease fifteen years previously; and that at the present time his son, twenty-one years of age, was ill with the disease, having gone to bed on September 18. It was a part of the son's duty to assist his father in the collecting and delivery of the milk, and it was noted that several days preceding his going to bed he was in a somewhat weakened condition, probably from the invasion of the disease. It was further ascertained that at Mr. B's farm seven cases of typhoid fever were present, the first one coming down with the disease on September 11. The six other cases came down on or about the 20th of the month, which would indicate that the infection of the latter was obtained directly from the first patient.

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\* *Jr. of Hygiene*, I., 422. 1901.

† 32nd Report of State Board of Health of Mass., p. 803. 1900.

"The first case at the B. farm was a boy nineteen years of age, who assisted his father in milking and supplying the milk to Mr. A.; and it is a significant fact that at the same time a relative of his visiting the house and using the same spring water was afterward taken ill at his home with the disease, thus confirming the supposition that the original infection existed on this farm."

Dr. Eberstaller,\* health officer of Gratz, states that, in the district over which he has jurisdiction, typhoid fever is a great rarity, so that when cases occur he can afford the luxury of a thorough investigation of the etiological points in the cases. On June 20 of this year three persons were received into the hospital with symptoms indicating typhoid fever. One of these persons was a jurist, one an educated artisan, and the other an assistant in the Medical Institute of the University, people who can be trusted to observe and report facts correctly. All these persons declared emphatically that the infection in their case must be referred to a gathering which they attended on the 4th of June. Further than that they could give no information. Investigating the circumstances I learned of sixty-six persons who were present at this gathering. Among these sixty-six persons typical typhoid fever occurred in eleven, the diagnosis being confirmed by positive Widal reaction. Twelve other persons suffered from loss of appetite, and part of them had headache, disturbance of the digestive tract, etc. All these twenty-three persons visited a particular hotel or restaurant where they had drank milk. So far as could be learned persons who had not visited this restaurant or who did not drink milk there remained well. Only two persons among the sixty-six who drank milk in that place remained well. Further investigation disclosed the fact that the milk was brought to this place from a neighboring farm and in the farmhouse there were five typhoid fever patients.

At the Folkestone Congress a paper was read in which a case was mentioned of an individual who, for more than two years, was employed to milk cows in several different towns and farms of Kent. Wherever he went cases of typhoid fever occurred among those who drank the milk of the cows which he tended. The names and the fullest details were given, and typhoid fever

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\* Deutsche Viert. f. öff. Ges., XXXVIII., 59. 1906.

only ceased when the man, having thus injured his own son's business, was persuaded to give up altogether his occupation of tending and milking cows.\*

This man was undoubtedly a "bacillus carrier," as those persons are now designated who, after a typhoid infection, continue to excrete the bacillus for months and sometimes for years afterward.

In an outbreak of typhoid fever which occurred in the town of Adams, investigated by Dr. Morse,† it was found that the patients had all obtained milk from one dealer. He obtained his milk from two farms in another adjoining town, it being brought to the dealer's home in Adams each afternoon and distributed by him personally early the next day. On November 5 he began to feel poorly, but still continued to work until November 11, when, on account of lack of strength, he gave up work and remained at home. The family physician made the diagnosis of influenza, but he was sufficiently sick to remain at home until December 2, when he again went to work on his milk route. But on December 8 he was obliged to give up work for the second time. He lost some weight and considerable strength. Suspecting typhoid fever, Dr. Morse obtained a specimen of blood from him, and a positive Widal reaction was obtained in the laboratory of the State Board, indicating that his sickness was undoubtedly typhoid fever, and the subsequent development of cases among his customers seemed to indicate that such was the fact, for he began to be ill November 5 and it was not until November 15, ten days later, that any of his customers became ill with the disease.

In an outbreak of typhoid fever in Louisville, Kentucky, it was found that most of the cases, forty-four of them, could be traced to the milk delivered from one particular farm, which itself, together with the milk house and the cow house, were unexceptionable. The water used in washing the cans was badly polluted. Dr. Bailey, who investigated the outbreak, required that the water be boiled before it was used for cleansing the cans. The man innocently remarked that he invariably

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\* Public Health, XVI., 751. 1904.

† Thirty-third Annual Report of Mass., p. 559. 1901.

washed the cans with boiled water, but rinsed them with cold water afterwards.\*

Aside from milk itself, there is the possibility of the transmission of typhoid fever by some of its products.

Fraenkel and Kister undertook some experimental work for the purpose of determining the fate of the typhoid bacillus in buttermilk. Their results indicated that small quantities of the typhoid bacilli inoculated into buttermilk are not destroyed by the acids contained in it within forty-eight hours, a length of time which scarcely ever elapses between the period at which the buttermilk would be likely to be infected and its consumption. The possibility of infection through buttermilk must therefore be admitted.

Heim (cited by Laser†) published the results of his investigations concerning the length of time during which cholera, typhoid, and tubercle bacilli may retain their life in milk and butter.

In cheap kinds of rancid butter Heim was able to recover colonies of typhoid bacilli three weeks after the bacilli had been mixed with the butter. After four weeks, however, he was unable to do so.

Bruck‡ says that typhoid bacilli may retain their vitality twenty-seven days in butter and that the origin of typhoid fever may sometimes be referred to infected butter.

According to Lydia Rabinowitsch§ the typhoid bacillus retains its vitality but a very short time in cheese.

*Typhoid from Oysters.*—Among the food products which serve as disseminators of typhoid fever, raw oysters undoubtedly stand next to milk. The following may be taken as representative of outbreaks of typhoid fever due to infectious oysters:

In 1894 a serious outbreak of typhoid fever occurred at Wesleyan University, and Professor Conn of that institution traced it to polluted oysters. Other possible sources of infection could be excluded. Nearly all of the victims of typhoid fever were members of three of the seven college fraternities. On October 12,

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\* Rpts. and Papers of the Am. Pub. Health Assoc., XIX., 264. 1893.

† Zeit. f. Hygiene, X., 513. 1891.

‡ Deutsche Med. Woch., XXIX., 461. 1903.

§ Centr. f. Bak., (Ref.), XXXIII., 205. 1903.

eight days before the appearance of the first symptoms, all seven of the fraternities had their initiation ceremonies and had celebrated in the usual way with a supper. No other dish except oysters were from a common source and could in any way be incriminated. Four of the societies had their oysters from a local dealer, one of them took their oysters cooked. Of the remaining three two had no oysters, and the third had some from another source. The oysters from the local dealer which were received by the three societies in which the cases of typhoid fever occurred, were served on the half shell.

It was learned that at these same suppers quite a number of persons present were not students at the college. Some of these were a number of the alumni of the college and five students from Yale. Among the alumni there were several cases of slight illness which appeared at the same time with the cases of typhoid fever at the university, and in addition to these there were four cases of genuine typhoid fever among the alumni. Of the five Yale students who attended the banquet, two developed typhoid fever. It was learned that the oysters came from a place near the outlets of a number of private sewers, and that in a house from which one of these sewers came there were two cases of typhoid fever one of which proved fatal. These two cases of typhoid fever occurred at the proper time to be considered the source of the infection which the oysters carried.

Extending the inquiry to other places it was learned that seven students at Amherst had typhoid fever. One of these students contracted typhoid fever at his own home, and the remaining six attended a banquet on the same date as the banquet at the Wesleyan University, and, at the Amherst banquet, raw oysters from the same source as those which caused the Wesleyan outbreak were served. One young man from Boston who was at Middletown about the date of the banquets came down with an extremely severe case of typhoid.

George A. Soper, Ph. D., a sanitary engineer, of New York, presented\* a comprehensive and lucid history of an outbreak of typhoid fever at Lawrence, N. Y., due to oysters. The total number of cases of typhoid fever of which he had knowledge was thirty-one. There were three deaths. None of the cases were

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\* Medical News, LXXXVI., 241. 1905.

due to insanitary conditions, and the water and milk and other food supplies could be excluded in the search for the cause of the outbreak. More than two-thirds of the cases were traced directly or indirectly to shell-fish taken from water polluted with sewage. In the report it is said that at least two hundred times as many oysters and clams were shipped away as were eaten in the vicinity, and it was thought possible that thousands of cases of typhoid fever may have been caused among the people who ate those oysters. In the judgment of the reporter pollution of Jamaica Bay by sewage was the cause directly or indirectly of twenty-one of the thirty-one cases with which the investigation was concerned, and that the conditions found there fully warranted the opinion that, not only have the oysters and clams taken from these waters been unsafe to eat, but their shells have been dangerous to handle.

Sears\* reports on typhoid fever in the city hospital from the first of January to the middle of November, 1903. There were two hundred and three cases which came under his observation and they were furnished by two distinct epidemics. The first of these outbreaks of typhoid fever fell upon a colored school, the pupils of which, during an excursion down the harbor, amused themselves by digging and eating clams.

Sir William Broadbent has found many cases of typhoid fever in his practice among the wealthy classes of London, which were traceable to the eating of raw oysters. One of the cases he saw was that of a young woman in which the sanitary arrangements of the house were perfect. The water and milk which she had taken had been boiled. No other inmates of the house were sick in any way. She had eaten oysters ten days before she came down with typhoid fever.

In another instance he visited two young men living in the same house in which there had been no history of any other cases of typhoid. The house and the place of business where both of these young men were employed were in good sanitary condition. They were both attacked at the same time with typhoid fever in an unusually severe type for which there was no other cause except that ten days before the appearance of any symptoms

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\* Boston Med. & Surg. Jr., CXLVIII., 142. 1903.

they had eaten an oyster supper together. Both cases terminated fatally.

A young woman and her cousin had on two occasions eaten a half dozen oysters. The young women came down with typhoid fever ten and fourteen days respectively, after eating the oysters, the one in London and the cousin in Italy, whither she had journeyed.

A man and his wife both came down with typhoid fever at the same time in a house which was sanitarily perfect. No possible cause was apparent other than the fact that two weeks before they had eaten oysters.

Dr. Broadbent was called into the country where typhoid fever was unknown, to see a clergyman and his daughter who were both suffering with typhoid fever. Investigations could disclose no other cause for the disease save that about two weeks before they had twice had oysters from London, and they alone had eaten them.\*

Sacquéepe† had under his observation in Rennes a number of cases of typhoid fever which were undoubtedly referable to the eating of oysters. Particularly noteworthy were the cases of four women who together ate a basket of oysters. Three of them were attacked with typhoid fever, while the fourth, who a while before received a protective inoculation against typhoid fever, failed to take the disease.

Dr. Newsholme,‡ Medical Officer of Health of Brighton, England, has shown that of the cases of typhoid in Brighton, of local origin, in the four years 1893-1897, 33 % of them were traceable to shell-fish.

Whittier§ reported an outbreak of typhoid fever at Marion, a summer resort on Cape Cod.

A house party of six sat down to oysters on a blazer, three of the number had typhoid. A plain or even fancy roast is mere child's play to a microbe that hibernates in a cake of ice and comes up smiling the next summer.

Blenkinsop's Cove, a mile or more long, on the eastern side of the harbor and about a mile across from Marion Village, had

\* British Med. Jr.—Revue d'Hygiene, XVII., 246. 1895.

† Revue d. Hyg.—Hyg. Rundschau, XIII., 1903.

‡ Annual Rpt. for the Borough of Brighton, p. 24. 1897.

§ Boston Med. & Surg. Jr., CXLIV., 444. 1901.

been the chief source of the supply for the summer trade, until in midseason the demand increased and emergency calls arose; then, for convenience in quick delivery, etc., the clean oysters from across the harbor were kept in storage in places polluted by filth and contaminated by sewage. The State Board of Health reports the bacillus coli communis in oysters taken from various places on the village side, none in oysters from Blenkinsop's Cove.

These instances show the danger from the consumption of oysters in the raw state which have come from unsuitable places. There is nothing in the histories of outbreaks of typhoid fever referable to oysters to indicate danger in oysters from clean waters. Invariably, when the source from which the oysters have come has been learned, they have come from waters which have been exposed to sewage pollution. If the oyster industry is to escape severe losses, and the lives of people who consume oysters are to be duly safeguarded, comprehensive legal provisions should be forthcoming forbidding absolutely the "fattening" of oysters near the outlets of sewers.

On the experimental side of the question, the following has been brought out:

In the experimental work of Professors Herdman and Boyce\* in the artificial feeding and cultivation of oysters and on the action of sea-water upon the growth of the bacillus of typhoid fever, the following points were developed. In sea-water at a temperature of 35 degrees C. the bacillus lives two weeks, and in cold water it was found at the end of three weeks. Oysters which have been infected with the bacillus clear themselves pretty rapidly when subjected to a running stream of pure, clean sea-water. There was a great diminution or total disappearance of the bacillus in from one to seven days.

Dr. Klein's experiments leave no doubt that the typhoid bacillus can live for many days in sea-water and sewage, and that, when oysters have been laid in such mixtures, the organisms can be found within the shells.†

Prof. Hewlett‡ of Kings College, London, refers to the experiments of Klein, and then describes his own experiments

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\* Public Health, IX., 60. 1897.

† Jr. of State Medicine, V., 73. 1897.

‡ Jr. Preventive Medicine, XIII., 779. 1905.

which also show that oysters from polluted localities rapidly clear themselves of *Bacillus coli*, thus indicating that this bacillus is foreign to the oyster and is rapidly destroyed by it. It follows from these experiments that both the *Bacillus typhosus* and the *Bacillus coli communis* are microbes alien to the oyster, and when present in it must have been derived from the surroundings.

*Typhoid Fever from Other Food Products.*—Probably outbreaks are occasionally due to the infection of articles of food, other than milk and oysters. Circumstances have sometimes thrown suspicion upon vegetables eaten raw, particularly celery and lettuce grown upon ground enriched with a fertilizer containing human excreta, and in England, cress grown in polluted water.

Experimental work was carried on by Clauditz\* for the purpose of determining the degree of danger of transmitting typhoid fever through the medium of plants and vegetables which are consumed in a raw condition. He found no difficulty in demonstrating the presence of living typhoid bacilli on the surfaces of plants which had been grown in earth contaminated with the bacillus of typhoid fever, and he found that simple washing of the surfaces of these vegetables did not suffice to remove the pathogenic bacteria.

There are two possible ways in which bread may communicate infection. If mixed up with polluted water or other material, or the dough infected with unclean hands, the sterilization of the interior of the loaf is not absolutely certain, particularly as much American bread is underdone. Drs. Waldo and Walsh† cultivated thirteen different microorganisms from the center of loaves of bread soon after they were baked. This danger is slight in comparison with that of infection with dirty hands or otherwise after the bread is removed from the oven. The conditions of the bakeries which the English investigations have disclosed, suggest that the bakeries in every country should be kept under official sanitary control,—direct communication of the bakeroom with water closets, flooding with sewage, which in one instance at least was stopped with the rolling-pin, flies swarming the bakery which had free access at the same time to sources of filth,

\* Hyg. Rundschau.—Revue d'Hygiene, XXVII., 550. 1905.

† Lancet, 1894. Vol. II., 906.

want of ventilation and the bakerooms used as sleeping quarters, etc.

The experiments of Troitski\* showed that the bacillus of typhoid fever can retain its vitality upon the crust of a loaf of white bread or upon the softer middle portion, from 25 to 30 days or more. Upon rye bread the life of the bacillus was much briefer.

It should be remembered that the danger from an infected water supply is not always escaped by using bottled or aerated waters, soda water, or beer. These drinks, recently prepared from infected water, lose their infectivity only after some time.

The investigations of the Imperial Board of Health of Germany, disclosed the fact that the typhoid bacillus may remain alive and dangerous for five days.†

Dr. Eberstaller,‡ at a meeting of the German Public Health Association in 1905, gave the following histories of an outbreak of typhoid fever in which the infection was transmitted through the medium of bottled beer:

The persons affected were mostly of the better class. There was a total of twenty-four cases. An investigation disclosed the fact that the beer which was incriminated had been bottled by a man on the third day of his illness which had necessitated his removal to the hospital where he had a run of typhoid fever. On the day while engaged in this he was suffering from severe diarrhoea. In filling the bottles he made use of a rubber tube through which he sucked the beer to start the siphon, and handled the end with his fingers which were inserted into the mouth of the bottles to be filled. This investigation led to the establishment, under official regulations, of less objectionable methods of filling beer bottles.

*Air-Borne Infection.*—Indoors, in infected rooms, or in handling infected clothes dry, infection may occur, but in the open, under the conditions in ordinary life, distribution or infection through the air is hardly worth considering. But in the report on military camps, already quoted, the authors state:

"It is probable that the infection was disseminated to some extent through the air in the form of dust. So prevalent was typhoid fever at Chickamauga that much of this fecal matter

\* Revue d. Hygiene, XVI., 726. 1894.

† Arbeiten a. d. Kaiserl. Gesundheitsamts. II., 15. 1887.

‡ Deutsche Viert. f. öff. Ges., XXXVIII., 60. 1906.

must have contained the Eberth bacillus, and it seems hardly possible that the great clouds of dust in which the men lived could have been free from this infection. The shell roads through the encampments at Jacksonville were ground by the heavy army wagons into an impalpable dust several inches thick. Along these roads scavengers carted in half barrels fecal matter containing the typhoid bacillus. The contents of these tubs frequently splashed over and fell in this dust. On each side of these roads soldiers were encamped, and many mess tables were in close proximity to the roads. Local whirlwinds sometimes caught up large quantities of this dust and carried it considerable distances. After seeing these things, we feel that we can not exclude the dust as a probable carrier of the typhoid infection, notwithstanding the fact that it would probably be a very different thing to scientifically demonstrate that the disease was disseminated in this way.

Tooth\* assigns four causes for the prevalence of typhoid fever while he was in camp on Modder river in South Africa in 1899: First, the water of the river of which the soldiers could not be restrained from drinking; second, infection in the dust which was blown about by the winds; third, flies; fourth, direct infection from person to person.

*Other Sources of Infection.*—There are possibilities of infection from an infected water supply in the home even when it is not used as drinking water. In the report of Reed, Vaughan and Shakespeare, already cited, two cases of typhoid fever are narrated in persons who did not drink the infected water but used it with their toothbrushes; and two more who gave themselves treatment with the nasal douche, using the infected water for this purpose.

*Primary and Secondary Cases.*—In outbreaks of typhoid fever there is often a great difference in the history of the primary and the secondary cases. The earlier cases may have been due to an infected water supply or milk supply and have developed suddenly, while subsequent cases, due to contact infection, transmission by flies, or the infecting of home environments, may prolong the prevalence of the disease and present an epidemiologic picture different from that which was seen at first. Thus conflicting opinions may be held as to the cause of the disease by persons whose observations do not take in the whole field of the epidemic as regards time and territory.

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\* Lancet, 1901, Vol. I., 79.

Referring to the study of the epidemiology of typhoid fever made by the French school and particularly by Bretonneau, Almquist\* remarks that in their works the unprejudiced reader is compelled to acknowledge that cases of typhoid fever imported into small places where subsequently the course of the disease may easily be studied, show that typhoid fever is a contagious disease and is exceedingly dangerous for the neighborhoods. As a corrective of certain localistic theories I can heartily recommend the study of their works, but a detail relating to typhoid infection well known to earlier French observers has, it is strange to say, disappeared from the text books on typhoid fever.

Almquist here refers to the fact that the period between the appearance of the first case of typhoid fever and the next following cases is from three to four weeks. As Gengron says, a few of the secondary cases appear within a briefer period of time, but they are the exception to the very general rule. He further affirms that the incubation period for typhoid fever is seldom longer than from eight to ten days and occasionally very short.

Piedbache who studied typhoid fever in rural hamlets or villages, observed 452 cases between the years 1839 and 1848. He reports that typhoid fever had extended itself in a very uniform way, to wit: that between the primary and the secondary cases from three to four weeks elapsed. He describes in detail many house epidemics in which this rule is observed. The secondary cases appear most frequently when the primary case was in the fourth week.

Almquist narrates the following in his own experience as illustrating this point. A servant girl became sick August 8, and was carried to her peasant home August 18. After her arrival from the 12th of September on, several of the members of her family, her parents and brothers and sisters, became sick with typhoid fever. Several persons in the city, who received milk from this house, became sick from September 17th on. There was, therefore, a period of about four weeks after her return home before new cases of the disease occurred among the persons who came in contact with her, although in the small and thickly populated house there was no isolation whatever. He

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\* Zeit. f. Hygiene, X., 163. 1891.

refers to other similar personal experiences of his own and of his associates.

Almquist therefore enumerates the following rule: When a case of typhoid fever gives rise to secondary cases, these appear, as a rule, not until from three to four weeks have passed and then it often occurs that several persons who have been exposed to the first case come down simultaneously.

Von Rieder in reporting an epidemic of typhoid fever in Riga in the year 1900, states that this outbreak was caused by an infected water supply, but that in connection with the outbreak there were a large number of secondary cases in which the infection was from person to person. One of the house physicians in the hospital and thirty-eight of the nurses attending the cases of typhoid fever came down with the disease, and several outbreaks in families strongly indicated contact infection.

*Atypical Cases of Typhoid Fever.*—To require every case of typhoid fever to conform with the text-book picture of typical cases would be a practice extremely dangerous to the public health. Very atypical cases of typhoid fever, as well as of other infectious diseases, frequently occur, and the delay in expressing a positive opinion on these difficult cases, is creditable to the attending physician, the sanitary precautions required under such circumstances being observed meanwhile, for the infection is often present early in the stools of mild typhoid and of atypical cases.

Dr. C. E. Woodruff,\* surgeon U. S. army, says:

“Investigations by Widal's test have shown that typhoid infection can exist in myriad forms even without intestinal lesions, and the atypic forms thus assume a great military importance. Every such case introduced into a crowded camp may infect the whole army so as to disable it, even though the original patient is not bedridden. The serious typhoids with abdominal symptoms are of no military importance, for every one recognizes them. The real danger is in the short mild cases in which the patients are allowed to run about, spreading the infection broadcast—the cases which local pride or fear of public condemnation leads so many physicians to call a ‘touch of malaria’ or ‘biliousness’ or any other non-committal diagnosis. Not less dangerous are the atypic cases without abdominal lesions, but having the infection confined to the lungs, kidneys, meningies, bones,

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\* American Medicine, VIII., 1091. 1904.

or indeed any other part, for no tissue seems to escape. It is believed that these cases constitute a large proportion of all the infections. Osler reports the case of an old man who died of pneumonia, from whom pure cultures of the typhoid bacillus were obtained from the lungs, spleen and other organs, and yet there were no intestinal lesions.

In a paper on mild and abortive forms of typhoid fever Dr. Briggs,\* of Washington, D. C., says:

"Probably no one of the common infectious diseases has so many points of interest for us, both as citizens and as physicians, as has typhoid fever. Many an epidemic of typhoid fever, whose origin is officially traced to a perfectly constructed water-supply system, should rather be laid at the door of the medical attendant upon the early, often imported, cases, who has been satisfied with a purely formal disinfection of stools and urine, either taking the most superficial precautions, or recommending the use of disinfectants of notorious inefficiency.

"A diagnosis of 'simple fever,' or of a gastric upset, is fatally easy to make, especially as in most instances no immediate unpleasant consequences will force attention to one's error."

Reviewing the typhoid fever condition in the Spanish-American War, Dr. Anderson,† of Washington, D. C., says that "it should be a golden rule that every case of continuous fever be considered typhoid until proven otherwise."

"Typhoid fever" says Drigalski, "assumes varied forms. Sometimes it is masked, sometimes it resembles influenza, bronchial catarrh, or even pneumonia, or gallstone colic which may be caused by the bacillus in the gall bladder. Gastric or intestinal catarrh should be considered suspicious, and so should various forms of angina. The typhoid bacillus may be present in persons who present a complete picture of health. Particularly in children typhoid fever assumes an atypical form."

Bezancon and Philibert state that the typhoid bacillus may produce a general blood infection without local intestinal lesions. They narrate fifteen cases of this form of typhoid intoxication. These cases were distinguished by the absence of abdominal symptoms, of the characteristic eruption, and of marked enlargement of the spleen. In the severe forms of Eberth's infection the presence of the typhoid bacillus is constantly present in the general circulation. This form of the disease can be considered

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\* American Med. VIII., 644. 1904.

† American Medicine, III., 476. 1902.

as a general infection with or without secondary localizations in the intestinal tract.

In a second memoir on this subject in the same journal, the authors repeat that the typhoid bacillus may not only produce the specific blood poisoning without the appearance of localized lesions, but the infection may localize itself upon almost any organ of the body, with or without a tendency to general infection. Seventeen observations were made in which meningitis, lobular pneumonia, inflammation of the gall bladder, of the kidneys, the joints, and of the glands, were referable to the typhoid bacillus. The enlargement of the spleen may constitute the only typhoid symptom.

In these cases the diagnosis can be made only with the help of the Laboratory—diazo-reaction, sero-diagnosis, cultures from the blood and feces. There is some difficulty in making a diagnosis between these forms of typhoid fever and paratyphoid fever.\*

In a paper read before the New York State Medical Association Dr. Louis C. Jaeger of New York, took up the subject of typhoid fever in children. He said that by no means all the members of the medical profession had yet divested their minds of the old fallacy that typhoid is a very rare condition in young children. In a summary of his paper the doctor says that typhoid fever in children is almost invariably of brief duration and that the temperature, as a rule, is not excessive.

On the other hand, Dr. Morse† of Boston, in a paper on "Infantile Typhoid Fever" expresses the opinion: "In the light of our present knowledge, the symptomology of typhoid in infancy is essentially the same as in adult life, and it is really and not apparently infrequent at this age."

Weichardt‡ describes a case of typhoid fever in the course of which the predominating symptoms were referable to the central nervous system while those which are considered pathognomonic for typhoid fever were wanting. The autopsy gave no distinct points for the diagnosis of typhoid. The bacteriological investigation, however, gave the typhoid bacillus with all its specific

\* Journ. de Physiol.—Centr. für Bak. (Ref.) XXXVII., 233. 1905.

† Medical News, LXXXIII., 193. 1903.

‡ Zeit. f. Hygiene, XXXVI., 440. 1901.

characteristics. Weichart considers such cases as this in which the diagnosis of typhoid cannot be made, and in which the necessary precautionary measures, including the disinfection, are disregarded, as extremely dangerous from the point of view of the public health.

Velich\* reports on thirty-six sudden deaths in which at the autopsy typhoid fever was found to exist. In twenty-five of the cases, in addition to the typhoid fever, disease of the heart was present, and in all the remaining cases there was other severe disease present. During the illness typhoid fever was not suspected and was first recognized at the autopsy. These cases of latent typhoid fever have great significance from the public health point of view.

In a discussion before the New York State Medical Association in 1905,† on the frequency of types of abrupt typhoid fever, Dr. Manges said that this form of typhoid fever, abrupt onset, is much more common than has been supposed, and as it is likely to be severe and needs treatment early it is necessary the diagnosis should be made at the earliest possible moment. In Dr. Manges's experience and according to the records of the Mt. Sinai Hospital, about ten per cent. of all typhoid cases begin abruptly. The causes of the sudden onset of symptoms in these cases seem to be the silent progress of the bacilli until all resistance is overcome when the organism gives way. There are two forms: the first is the genuine abrupt typhoid fever, and the second, the apparently abrupt. These latter are walking typhoid cases. Some of the cases resemble paratyphoid and in these the Widal reaction is the best possible diagnostic sign; in other cases the headache is so severe as to simulate meningitis. In some cases the temperature is extremely high. Sharp, hard chills occur in about two per cent. of the cases.

Dr. Stockton, of Buffalo, said, whenever typhoid fever selects a special organ for its attack, then the symptoms of its presence are almost sure to announce themselves suddenly. Dr. Moriarity, of Saratoga, referred to groups of cases of typhoid fever occurring in the hospital; four nurses, two orderlies, and three patients. None of them had prodromal symptoms. In two of

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\* Arch. f. Hygiene, XLIX., 113. 1904.

† Medical News, LXXXVII., 380. 1905.

the cases there was so much abdominal pain that they were thought to be cases of appendicitis. One of them was decidedly hemorrhagic in character and ran a severe course. All of them had slow pulses.

In the report of Reed, Vaughan and Shakespeare, several times quoted in these notes, it is affirmed: "It is altogether possible for an individual to carry in his alimentary canal and eliminate therefrom the Eberth bacillus in virulent form without having the disease himself. The probabilities are that the majority of men who reach 40 years of age have at some time or another carried this germ in their bodies, and this may account for the fact that men of this age are less susceptible to the disease than younger men."

Jürgens\* of Berlin holds that the presence of the typhoid bacilli is far from being synonymous with the disease. Following Koch's example, all the infected persons in an infected family were examined for typhoid bacilli, regardless of whether they were sick or well. This revealed a number of slight, atypical cases of typhoid, and also disclosed the presence of the bacilli in certain absolutely healthy subjects. The bacilli in the milder cases were sometimes far more virulent than in the severe ones. The resistance of the individual is evidently the determining factor. The disease process is identical for all, but differs in its degree.

Conradi† relates that in the discharges from the bowels of a child sick with typhoid fever, in addition to numerous typhoid bacilli, a number of paratyphoid bacteria were found (on Drigalski-Conradi plates). The infection was supposed to have been received in ice which the child consumed. Symptoms of the fever appeared eight days later. In the Municipal Hospital occasionally an epidemic of typhoid fever occurs referred to contact infection. In the discharges of some of the sick, typhoid bacilli may be found, while in those from other patients the paratyphoid bacilli are present. A physician who was not sick discharged by stool both typhoid and paratyphoid bacilli, while, at the same time, his serum possessed no power of agglutination. The bacteriological investigation was made twice within eight days.

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\* Public Health, XVI., 751. 1904.

† Centr. f. Bak. (Ref.) XXXV., 764. 1905.

Two years ago, says Fischer,\* we had an outbreak of typhoid in Kiel in which there were eighty cases, and, after a careful investigation of the circumstances, we were forced to conclude that the disease was due to the eating of the meat of a sick animal. This experience is not unique. Three years previously we had a similar experience. In a small place near Kiel fifteen persons suddenly were attacked with typhoid fever, and the persons exclusively were attacked who had eaten the meat from a sick calf. Similar epidemiologic observations have come from the province of Plon. In the Kloten epidemic also 600 of the visitors to a music festival became sick after partaking of meat which had been derived from a sick animal. In the epidemic at Kiel of which I have spoken, in which the disease presented the appearance of typhoid, the paratyphoid bacillus was found instead of the true typhoid bacillus.

I may add that last year we had an epidemic in a small city in which there were sixty cases which presented generally the typical clinical picture of typhoid fever, yet we were unable to find either the specific typhoid bacillus or the paratyphoid bacillus in the dejections or in the blood. This and some similar experience force us to the conclusion that, aside from typhoid bacilli and the two hitherto described paratyphoid germs, there must be other unknown bacilli which sometimes cause a disease identical with typhoid fever or closely resembling it.

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\* Deutsche Viert. f. off. Ges., XXXVIII., 57. 1906.

## NOTES ON DYSENTERY AND CHOLERA.

By the Secretary of the Board.

These few notes are presented for the purpose of bringing out the parallelism which exists between these two diseases and typhoid fever, so far as the methods in which their distribution is concerned. These three diseases are the chief components of a group which have been known as water-borne. While the rapid spread of typhoid fever and cholera through the medium of infected water supplies has constituted the most dramatic phase of their epidemiology, we need to grasp clearly the teachings of the observations of recent years, that these diseases are largely spread irrespective of water as a medium of transmission, and often in fact when the influence of water supplies can entirely be eliminated—spread directly from person to person, by “contact infection,” favored usually by the unclean environments of the people.

*Notes on Dysentery.*—In a report on an outbreak of dysentery in the Connecticut Hospital for the Insane in 1903, Drs. Diefendorf and Fisher\* state that the origin of the epidemic could not be traced to sources outside the hospital, including the food, water, and milk supply. A considerable majority of the cases they think resulted directly or indirectly from contact with infective material in the hospital—dejecta of patients. The bacillus dysenteriae was recovered in one-third of the cases studied.

Following the Franco-German war of 1870 and 71, says Röttger,† there was a marked increase in the prevalence of dysentery. The susceptibility to dysentery is about the same at all periods, but the mortality rate is much greater in the earlier years and again at the advanced period of life.

An outbreak of dysentery occurred in Bremen in July, 1899. A careful investigation showed that, as early as the end of June

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\* 26th An. Rept. State Board of Health of Conn., p. 234. 1903.

† Centr. f. allg. Ges.—Deutsche Viert. f. öff. Ges., XXXIII., 167. 1902.

in some houses on the streets in which the outbreak occurred, there had been cases of intestinal disease which were probably dysentery. In what way the infection was first introduced has not been explained, but the disease spread slowly, first in the families of the sick, until the beginning of September, when there was a rapid increase in the prevalence of the disease. The outbreak reached its maximum in the third week of that month with 130 cases. There was a total of 591 cases with 66 deaths. It was observed that the disease gradually spread from house to house and from street to street. The infection of the drinking water could, therefore, apparently be excluded, and the way in which the disease spread indicated contact infection or the extension of the infection from person to person as the result of injudicious association with the sick, and contact with soiled body and bed clothing of the sick, the infection of food with the hands of the sick or of the attendants upon the sick, etc. The social and sanitary conditions of the people in this part of the city were far from satisfactory.

An epidemic of dysentery which appeared in one of the German army barracks was investigated by Robert Koch\* and he could not find any reason to suspect that the infection had come through infected water supply, food, drink, or arrangements for the disposal of excreta. Koch came to the conclusion with the military surgeons that the barracks themselves were thoroughly infected. They were therefore vacated.

Borntraeger† reports on a widely distributed outbreak of epidemic dysentery which occurred in the region around Danzig, Germany, in the years 1895 and 1896, and furthermore gives much information in regard to the prevalence of the same disease in the same country in former years.

In one group of cases there was a total of 1,176 cases of the disease with 176 deaths, which was equal to 15 per cent. of them. His observations indicated that the average period of incubation of the disease was three days, ranging from two to six days. He gives many instances which indicate the correctness of his conclusions on this point. He is convinced that, as a rule, the

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\* Zeit. f. Med.—Deutsche Viert. f. öff. Ges., XXXIV., 163. 1903.

† Zeit. f. Hygiene, XXVII., 378. 1898.

infection of the disease is received by the way of the mouth; possibly occasionally by the way of the rectum. The infectivity of the specific organism of dysentery is very great, either that or the immunity of man against it is slight, for he had observed repeated instances in which all the members of a family of from five to eight persons were attacked, one after another, after a person sick with that disease had come to that house. The endemic history of the outbreak teaches him that the micro-organism must have a long period of vitality. Instances are cited in which it would appear that the infection must have retained its vitality from one to two or three years.

As to the method in which the disease is communicated he is convinced that it is largely spread by direct infection—by contact with infectious persons and with things which have been infected by the patient. The following are a very few of the many instances mentioned by him in support of his views:

A boy returned to his father's house sick with the disease. The result was the infection of his own family and later of other families in the neighborhood with whom they associated. Twenty cases resulted. A man brought the disease from Russia to one of the frontier towns of Germany. Forty-eight cases resulted. A girl was present at the burial of her brother who had died of dysentery. Returning to her home she came down with the disease. A young woman was present at the funeral of a relative. Returning she brought the disease to the town in which she lived and from this implantation of the disease sixty-two cases occurred with sixteen deaths.

A servant girl was brought to her brother's home in H. and infected his family, from which the disease was transported to three other houses in the neighborhood. Thirteen cases followed this implantation of the infection. Many other instances are given in which the disease was transported by persons who returned to their homes, and of persons who were infected by visiting the sick, or by being present at the burial of the deceased.

As regards the transmission of the infection through the water supply he makes these statements: the rapidity of the transmission is against the assumption of water-borne infection, for in numerous instances the persons became sick with the disease in from two to three days after their first exposure. This is

too rapid a transmission of infection to believe that reaching the ground it found its way to the water supply and thence to the patient.

Again the fact that the persons who were in the closest association with the sick ones were the persons who first came down with the disease. Other persons in the same house and persons in the neighborhood came down gradually one after another. The general method was not an explosive outbreak infecting many persons at the same time in a group of houses which used the same local water supply.

In the cities when the disease appeared in a family living several stories above the ground and spread from person to person, the influence of the ground as a factor in the local outbreak could with considerable confidence be excluded. Against the idea of the influence of the ground or the water supply in the propagation of the disease he refers to the fact that some of the regiments infected in the barracks were moved to other quarters in the open field. Nevertheless the infection clung to them and still further affected them after they had removed to other barracks.

Referring to the usual manner in which infection is spread, he reminds us of the conditions of the patient who has this disease with some twenty to sixty evacuations in 24 hours. Under the circumstances it is altogether impossible for the patient, even if of cleanly habits, to avoid the infection of his clothing, of his bedding, and of his hands, and eventually everything touched by him; clothing, eating utensils, and many other things in his vicinity are infected. The hands of the attendants, as can easily be understood, soon become infected, and there is great danger of the transmission by them of the infection indirectly to the lips or mouths through the medium of their food and otherwise. He observes that this sort of finger infection is exceedingly common not only in this disease but in cholera and in typhoid fever.

If this method of propagating the disease can occur in cleanly persons it may be imagined how much more favorable for this method of transmission it is among the uneducated and uncleanly persons in this class of people in the country.

Infection, in dysentery, occurs in the great majority of cases by the mechanical transmission of traces of fecal matter; that

in fact it has a direct fecal infection, and that the ground cannot be considered an etiological factor. Infection is transmissible directly from person to person. Practically considered, the presence of a person sick with this disease is as dangerous for his associates as would be the presence of a person sick with smallpox. The disease is transmissible in the same way as is the infection of cholera.

Accepting his theory, the explanation of some of the epidemiological histories of dysentery is made clear. It shows why the disease is more prevalent in the lower classes of the people. It explains in part at least why children are more frequently attacked than adults. They are less careful and less cleanly in their habits; they are handling everything, they stick their fingers and many other things in their mouth, and out-of-doors come more intimately in contact with sources of filth which may contain infection.

As in cholera the effects of the sick, and particularly of the body and the bed clothing are infectious. This is indicated by the history of a woman who became sick in Danzig after washing infected clothing, and by the case of a young woman in Krangen who became sick after using the clothing which had belonged to persons sick with this disease several years before.

Repeatedly Borntraeger found articles of food as probable carriers of infection in Danzig. Several families were supposed to have been infected through milk, cheese, fruit, or vegetables which had been infected. He admits the possibility of the transmission of this disease through water supplies, but in these outbreaks which he investigated he finds no logical indication that the disease was thus spread.

The control of epidemics of dysentery should be through isolation of the sick, care for extreme cleanliness of the patient and of the surroundings, and particularly of the patient's hands, the prompt disinfection and proper disposal of the excreta of the patients, the disinfection of all dishes and utensils used in the sick room, of the clothing and bedding, and of privies. Other persons in the same house must take precautionary measures observing utmost cleanliness, and particularly should they carefully cleanse and disinfect the hands after they have come in contact with the patient and with articles in the sickroom.

*Notes on Cholera.*—India has been considered the perennial home of cholera. The climate and the life conditions of the natives of that country favor the transmission of the disease from person to person and favor the continuance of the vitality of the infection in the outer world—in the soil and the earth. What some of the conditions are were described by Dr. W. J. Simpson, in 1894, then Health Officer of Calcutta.

“The tanks or ponds form a special feature in the physical topography of Calcutta. Originally excavated to raise the surrounding land in order that huts and houses might be built on the raised land, the tanks became useful, first, as reservoirs of rain-water for supplying the neighborhood, or the surrounding cluster of huts, with water for drinking and for domestic purposes; and, secondly, as a convenient receptacle into which the drainage of the locality should flow. Different districts differ in the number of ponds which they contain; some are honeycombed with these tanks, and during the rainy season there is actually in some areas more water than land; others have fewer tanks, and a number of them are protected from drainage pollution. The public tanks are also, as a general rule, well looked after; but the majority of tanks are the mere drainage cesspools of the locality. Much has been said regarding the filthiness of these ponds. They more or less resemble pea-soup in colour, and their composition has been officially reported as concentrated London sewage. The drainage from latrines often find an easy and convenient outlet into their waters; soiled clothes of the sick and of the healthy are washed therein; men, women and children bathe and perform their ablutions in the pond, while oxen, buffaloes, horses, goats and other animals are taken down to the water’s edge, and there given a bath. In such water the inhabitants cleanse their domestic utensils and soak, macerate and wash their rice and *dhal*, and not infrequently prepare other kinds of food.”

The spread of cholera from person to person requires the transference to the intestinal tract of new victims of some of the infection generated in the intestinal canals of the cholera sick. As in typhoid fever the transference may take place in various ways.

The large epidemics of cholera have been water-borne, though other factors have contributed their share to the distribution. Following the routes of traffic, cholera has several times spread from our Atlantic and Gulf ports, to which shipping has brought it, and prevailed disastrously at interior points, particularly in the valleys of the Mississippi and Ohio. Of late outbreaks, that of Hamburg, Germany, in 1892, illustrates the rapidity of the extension of water-borne epidemics of cholera. The water of the river Elbe, from which the city water supply was then taken unfiltered, in some way became infected with the bacillus of cholera. Within 18 days of the beginning of the outbreak the disease had spread rapidly over all parts of the city, and 10,000 cases had occurred with more than 4,300 deaths.

The outbreak of cholera in a hospital for the insane in Nietleben, Germany, in the beginning of 1893, is an example of the winter prevalence of cholera which is not by any means unique. The first case occurred in the middle of January. The next day there were six new cases, and the third day, eleven. There were one hundred and four cases in all, among them three physicians and ten nurses and women attendants. It was afterward learned that a man came from Hamburg, where cholera had prevailed, and after his arrival suffered from diarrhea, which later led the investigators to believe was cholera in a mild form.

Cholera is propagated by infected water, not only by drinking it, but, as in typhoid fever, the presence of infected water in the household constitutes a grave danger, for it may find its way into the stomach through the infection of dishes, tooth brushes, the hands, or lips in washing, etc.

In the ground the bacillus of cholera may retain its vitality some weeks at least under favoring conditions; and in water its life may be considerably prolonged. In one of the water tanks of India, investigated by Koch, the cholera bacillus was found for fifteen days. Out of forty-six water tanks around which cholera existed, near Calcutta, Simpson found the cholera bacillus in forty-two, that is, in 91.3%. Under the observations of Babes, the cholera germ remained alive in the water of the Seine seven days, and the same length of time in the water from the public supply of Berlin. According to Nicati and Rietsch,

it remained viable eighty-one days in the water of the harbor, sixty-four days in sea water, and thirty-eight days in canal water.

It has been shown that in or on some food supplies the micro-organism of cholera retains its vitality for some length of time, or even undergoes rapid multiplication. In his experiments on its behavior in milk, Kitasato found that, at the temperature of 36° C., the cholera bacillus developed very rapidly during the first twenty-four hours. They then diminished in numbers from hour to hour as the acidity of the milk increased. Aboard a ship in the harbor of Calcutta, nine cases of cholera suddenly appeared. An investigation showed that these nine persons and one other person, had received milk from a native milkman. The one person who was spared had taken but very little milk. Eight other persons aboard the ship who used condensed milk, and three who used no milk at all, remained free from the disease.

Uffelmann has shown that the bacillus, on the surface of rye bread open to the air, remained alive twenty-four hours, but when the bread is wrapped in paper it continued viable for three days. On roasted meat placed in a bell jar, it was active at the end of a week. It develops luxuriantly in bouillon, on potato, and, according to Babes, on fresh meat, cooked eggs, cabbage, moistened bread, and legumes. Various foods, therefore, not freshly cooked, which have been exposed to infection in various ways, may transmit dangerous doses of cholera infection.

The clothing of cholera patients, second hand clothes, scraps and rags especially, are to be regarded as particularly dangerous and a fruitful source of distribution of infection in cholera times. Upon dampened clothing and other fabrics, the bacillus will not only retain its vitality, but will sometimes increase luxuriantly. Washerwomen have been notoriously exposed to cholera infection. This was noted in Vienna in 1866. In a laundry in that city, sixteen of the women working there were attacked with cholera. In 1873, in the same establishment, there occurred first one case, then two other cases, at a time when there were only a few isolated cases of cholera in the city. It was shown, however, that cholera infected clothing had been sent to this laundry. Later, in the same year, another local outbreak of cholera occurred in this same laundry.

Attendance upon the cholera sick under suitable precaution is not considered especially dangerous. Some of the characteristics of the specific infection of this disease would appear to lessen the danger of contact infection, and perhaps lower the degree of this danger below that of typhoid fever. While the typhoid bacillus is noted for possessing a degree of resistance against adverse conditions exceeding that of many pathogenic bacteria, the bacillus of cholera is noted for its slight power of resistance against adverse conditions. It resists well low temperatures, but is easily destroyed by low degrees of heat, easily destroyed with disinfectants, quickly loses its life upon drying, but when subjected to drying under certain conditions in which desiccation is not perfect, it may retain its vitality some time; according to Uffelmann, on the printed page, seventeen hours, on writing paper in an envelope twenty-four hours, on textile fabrics in a dry state, four days, but when moist, twelve days.

The investigations made by the Imperial Board of Health, of Germany, showed that the disease may be transmitted by uncleanly hands, utensils, etc. The fatal case of cholera which occurred in the laboratory in Hamburg, in 1894, emphasizes the danger of contact infection.

Most of the experimental work relating to the cholera bacillus would lead us to the conclusion that there is little danger from air-borne infection, although this danger undoubtedly exists in uncleanly rooms where cases of cholera have occurred. The transmission of the disease through the air to any great distance appears to be entirely impossible. The cholera bacilli dried under certain conditions, for instance, with clay, sand, or sweepings, may be dispersed in the dust in a living condition, according to Liebermeister. There is good reason to believe that the infection may be carried by flies.

As with typhoid fever atypical cases, even so mild that they can be recognized only by the help of the laboratory, play an important part in the distribution of infection. The "Bacillenträger," that is, persons who have been exposed to the disease and have had but mild symptoms, or none at all, may for some time continue to be sources of danger to persons and to places by discharging cholera bacilli in their excretions.





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